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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 81.

B. T. GALLOWAY, *Chief of Bureau.*

THE PHILADELPHIA
NOV 21 1912
MUSEUMS.

EVOLUTION OF CELLULAR STRUCTURES.

BY

O. F. COOK AND WALTER T. SWINGLE.

VEGETABLE PATHOLOGICAL AND PHYSIOLOGICAL INVESTIGATIONS.

THE PHILADELPHIA
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T. D. BECKWITH, *Expert, Plant Physiology.*

---

[a] Detailed to Seed and Plant Introduction and Distribution.
[b] Detailed to Bureau of Chemistry.
[c] Detailed from Bureau of Chemistry.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., May 31, 1905.

SIR: I have the honor to transmit herewith, and to recommend for publication as Bulletin No. 81 of the series of this Bureau, the accompanying technical paper entitled "Evolution of Cellular Structures."

This paper was prepared by Messrs. O. F. Cook and Walter T. Swingle, and has been submitted by the Pathologist and Physiologist with a view to its publication.

The accompanying plate is necessary to a complete understanding of the text of this bulletin.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

PREFACE.

Ever since the epoch-making discovery of Charles Darwin there has been a steadily increasing influence of the theory of evolution on the scientific study and practical utilization of the plants and animals on which agriculture is based. The present paper marks a step in the further working out of the doctrine of descent, inasmuch as it embodies results of an association of the data won in two very different fields of investigation; one making the cell its object of study, the other occupied with the species. The results herewith presented open new views as to the nature of higher animals and plants which can not fail to stimulate research and which promise to have great economic significance in the determination of the actual and latent capacities of the organisms utilized by man.

A. F. Woods,
Pathologist and Physiologist.

Office of Vegetable Pathological
and Physiological Investigations,
Washington, D. C., May 8, 1905.

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EVOLUTION OF CELLULAR STRUCTURES.

INTRODUCTION.

The value of a new point of view lies in the fact that it permits new relations to be perceived. By means of the kinetic theory of evolution it has become possible to understand that organic development has been carried forward through gradual improvement of the methods of descent rather than by environmental causes. Instead of there being a law of heredity which tends to keep the individuals of a species uniform, or exactly alike, the tendency, especially among higher plants and animals, is to maintain, inside the species, a diversity of form and structure, most conspicuously manifested in the phenomenon of sex.

This intraspecific diversity is neither accidental nor incidental, but of great physiological and evolutionary importance. The interweaving of distinct lines of descent is necessary to sustain the strength and vital efficiency of the individual organisms, and to continue the evolutionary progress by which the species adapts itself to changing environments or enters new ones. Interbreeding is as indispensable for the species as for the individual, or even more so, for seedless plants continue their individual existences after the coherence of the specific group has been lost.

Normal and long-sustained evolutionary progress is not accomplished on single or narrow lines of descent, but is possible only for large companies of interbreeding individuals; that is to say, for species. It is thus no mere accident, but a fundamental necessity, which brings about the association of organic individuals into species and determines what might be called the specific constitution of living matter. Species are sexual phenomena; they have come where they are only through symbasis; that is, as groups of interbreeding individuals, traveling together along the evolutionary pathway.

This interpretation of familiar biological facts is supplemented and confirmed by the study of the processes of cell conjugation, which are the means of symbasic interbreeding. Among simple organisms conjugation is a periodical incident in the multiplication of equal and independent cells. Higher stages of organization were reached by the production within the same species of many kinds of cells and the building of these into large colonies or compound individuals. There was, however, a very early limit to the structures which could be

built of the primitive, simple type of cells, as illustrated by the filament of the lower alga, the vegetative mycelium of the fungus, and the thallus of the liverwort. The plant series would have culminated, apparently, with the leafy axis of the moss if the basis of organization had not been changed from the primary or simple type of cells to the double or sexual type.

In undifferentiated unicellular or equal-celled (isocytic) organisms the successive generations of cells may be thought of as joined into a network by an occasional conjugation. The cells at the knots of the network are, as we know, double, being formed from the association of two nuclei and the accompanying protoplasms. They are often strikingly different from the remainder of the cellular fabric of descent, and have been given special names, such as oospore, zygospore, and resting spore. In the first or lowest category of sexual organisms only one cell in each generation is double; there is only one large bead at each node of the genealogical network. (See Pl. I.) A second type of organic structure was initiated when an organism attained the art of forming two or more of these double cells by division.[a] It is of such double cells that all the higher plants and animals are built. The new type of organization was not merely supplementary to the old; it was a new biological invention, giving rise to a new category of vitality, which not only outstripped the old type of structural organization, but even caused it to be abandoned and eliminated as a worse than useless impediment.

Organisms which were farthest ahead on the primitive basis have fallen far behind since the new course of development was opened. In such groups as the liverworts, mosses, and ferns the diversity of the two types of organic structure is strikingly obvious, and has received extensive study for years past under the name of "alternation of generations." Ample homologies have been found in the highest groups of plants to show that the so-called alteration of generations was everywhere in ancestral condition, and that all have followed essentially the same history in having abandoned the simple type of cell for the double as the basis of structural development.

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[a] The terminology followed in this paper presupposes for convenience the existence of the cellular type of organization common to most animals and plants. The conclusions here reached apply with equal force, however, to organisms such as the Infusoria among the protozoa, the Siphonocladiaceæ among the algæ, and the Saprolegniales and Mucorales among the fungi, in all of which groups considerable structural differentiation is attained without any division of the organism into cells. Such forms as Caulerpa and Acetabularia among the Siphonocladiaceæ reach a considerable size and even show a well-marked differentiation into the analogue of stem and leaf, rhizome and root, without the enormously expanded thallus being divided up into cells at all, although very numerous nuclei arise by subdivision and are scattered throughout the cytoplasm. These nuclei could be double, in which case such plants would be directly homologous to the double-celled organisms described in the following pages.

That these converging data pointed to something of fundamental evolutionary significance has been confidently believed since the publication a decade ago of Strasburger's epoch-making essay entitled "The Periodic Reduction of the Number of the Chromosomes in the Life-History of Living Organisms,"[a] but a new evolutionary standpoint was required before the larger import of the facts could be perceived. The reduction of chromosomes is indeed a striking and unique phenomenon in the life history of organisms, and it naturally became the focus of interest in the rapidly developing science of cytology. A new point of view was the more necessary, however, because of an unfortunate choice of terms which has undoubtedly tended to prevent the perception of the true relations of the facts, as it now interferes with a correct description of them. We refer to the characterization of the higher, double-celled, spore-bearing "generation" as "asexual." Appreciating the primitive character of such structures as the prothallus in ferns, Strasburger asserted that a new "asexual generation" had been intercalated into the life history of organisms. It is now perceived that for cytological purposes this is not the whole truth, and that for evolutionary purposes it is not true at all. The new "generation" was not merely intercalated into the *life history* of the organism; it was intercalated into the *sexual process*. It is, therefore, not asexual, but sexual, and in a higher degree than the so-called sexual generation. The latter bears, it is true, the cells which conjugate, but the former is produced *during the actual process of conjugation*. Organic perfection has been attained, not through the development of an "asexual generation," but by the lengthening out of the sexual process itself; not by abandoning or avoiding sexuality, but directly by means of it.

Among the lower plants the single cell formed by conjugation accomplishes in a brief space of time all the cytological processes which in the higher plants come between fertilization and chromosome reduction. Sexual fusion is immediate and complete, and takes place during a brief period of interruption of the growth and subdivision of vegetative cells. If the vegetative fern prothallus is to be termed sexual because it produces antheridia and archegonia, the sporophyte is sexual to the second degree, for it is built of conjugating cells, containing, until synapsis and the subsequent reducing divisions, a double number of chromosomes, the parental chromatin elements being still unfused. However important chromosome reduction may be, it is, after all, only a corollary or sequel of the *doubling conjugation*. It was not the reducing division, but *the long postponement of the reduction division*, which permitted higher types of organisms to be developed by means of double, sexual cells.

A special evolutionary significance was ascribed to the chromosome

[a] Strasburger, Edward, Annals of Botany, 1894, 8: 281–316.

reduction because cytology was approached from the standpoint of the somatic tissues of the higher plants and animals. This current interpretation reverses, however, the historical course of events. The reducing division was not an expedient incidental to the adoption of a process of sexual reproduction by organisms previously sexless. *It was not the reduction to fewer chromosomes, but the retention of the double number, that constituted the important step in sexual reproduction and made possible the evolution of complex higher organisms.* It is, therefore, not the reducing division, but the doubling conjugation, which should constitute the datum point or base line for tracing cytological homologies.

THE ELIMINATION OF THE SIMPLE-CELLED PHASE.

Chromosome reduction brought about by synapsis, or the fusion of the chromatin elements, followed by two special nuclear divisions, is not, historically speaking, the beginning of the sexual process, but the end of it. Chromosome reduction stands in no special causal relation to the subsequent conjugation. The number of cell generations formed between synapsis and conjugation differs greatly in the various natural groups, and merely shows how far the organism still adheres to its old simple-celled life history. Fecundation and synapsis, as the beginning and the end of the sexual process, would seem to be directly comparable in all organisms which have developed a double-celled sexual phase.

From the physiological standpoint, it may be an advantage to dispense with the simple-celled phase and thus shorten the period between the chromosome reduction which marks the end of one conjugation and the cell fusion which begins another. Synapsis relieves organic fatigue by means of new nuclear configurations, and has been thought of as a stimulant of vital activity or energy of growth, the benefit of which can be secured for the new double-celled structure by very prompt conjugation, as occurs in all the higher plants and animals. This consideration would help to explain the organic inferiority of such a group as the ferns, which, although they have developed a double-celled phase, continue to waste the energy derived from synapsis on a worse than useless simple-celled structure.

In all animals above protozoa this reduction of the simple-celled phase has gone so far as to result in its complete elimination, for the two peculiar nuclear divisions which occur in rapid succession immediately after synapsis constitute an essential part of chromatin reduction. That these phenomena noted are indissociably connected stages in the process of chromosome reduction has been emphasized recently by Farmer and Moore,[a] who propose the convenient term maiosis to

[a] Farmer, J. B., and Moore, J. E. S. On the Maiotic Phase (Reduction Divisions) in Animals and Plants, in Quarterly Journal of Microscopical Science, n. s., No. 192 (vol. 48, No. 4), Feb., 1905, pp. 489–557, pl. 34.

include synapsis and the subsequent heterotype and homotype nuclear divisions.[a]

ALTERNATION OF STRUCTURAL TYPES.

"Alternation of generations" is an expression borrowed from zoology; its application to the archegoniate plants has introduced endless complexities, and can be justified, after all, only by false analogies. Alternation of generations was discovered by Chamisso in a species of Salpa, a marine animal belonging to the Tunicates; but here, as well as in the traditional zoological example of the Aphides, or plant lice, the phenomena have entirely different evolutionary significance from the so-called antithetic alternation of generations in the archegoniate. Generations or individual life cycles of Salpa and of plant lice, which were originally alike, have become different, so that now parthenogenetic generations alternate with sexual generations. To make the archegoniate plants a parallel instance, it would be necessary to assume that what is now called the sporophyte was originally another thallus, or something that corresponded to one, which later on became modified into the sporophytic "generation." To state the case in this way may seem quite superfluous, since nobody has made such a suggestion. Strasburger and others have repeatedly declared that the so-called asexual generation had been intercalated—that is, added anew—and not substituted for something else. This, however, makes it only the more obvious that the sporophyte is a generation only in a very loose and inaccurate sense, and not because it corresponds to or takes the place of any other generation. The simple fact is that, instead of forming merely one oospore as the result of fertilization, the archegoniates have come to form a whole sporophyte or double-celled structure by the multiplication and progressive sterilization of potentially sporogenous tissue, as Bower has shown.[b]

Bower's generalization is, however, only a half truth, since the sterilization, or, better, the arrest of spore formation of some of the cells, is conditioned on the possibility of continued subdivision and growth of the fertilized egg, and this can occur only when there is a definite

[a] To recognize, however, as Farmer and Moore do, these two cell generations as a distinct "maiotic phase" in the life history of Metaphyta and Metazoa does not seem warranted, since chromosome reduction is apparently a mechanical necessity resulting from sexual conjugation and is consequently brought about in a practically identical manner in all symbasic organisms, from the lowest to the highest. Maiosis is rather a connecting link at the node in the network of descent than a distinct phase subject to expansion or contraction as organisms mount in the scale of evolutionary progress. On the other hand it is clear that the two peculiar cell generations occurring during maiosis can not properly be classed with the double-celled phase that usually precedes or with the simple-celled phase that usually follows, but constitute a transition stage marking the end of one generation and the beginning of another.

[b] Bower, F. O. A Theory of the Strobilus in Archegoniate Plants. Annals of Botany, 8:343–365. 1894.

postponement of some stage of sexual fusion, for if the final stage is once reached and the chromatin fuses, no further growth is possible, and a new generation is inaugurated automatically. When sexual fusion is immediate and complete, i. e., when nuclear fusion follows close on cell conjugation and is in turn at once succeeded by chromatic fusion, no development of the oospore can occur; it simply breaks up into four spores. Such was once the fate of the eggs of all organisms, and such is still their fate in the lower plants. All development of the fertilized egg other than a simple splitting into four spores is due to an arrest of the process of sexual fusion which permits its expansion into a mass of double cells, such as constitute the bodies of higher animals and plants.[a] It is, however, clear that the effect of such an arrest in the process of sexual conjugation and consequent intercalation of a double-celled phase in the life history of the organism is to lengthen the life cycle; it lessens the number of generations instead of making more of them.

Notwithstanding half a century of endeavor, botanists and zoologists have not yet found in the higher animals any definite homologue of the so-called antithetic alternation of generations discovered by Hofmeister[b] in the archegoniate plants. The whole idea of alternating generations must, however, be abandoned and emphasis placed instead on the expansion of the oospore or fecundated egg into a double-celled phase that comes to occupy a larger and larger part of the life cycle as organisms mount higher in the scale of evolutionary progress. It then becomes evident that in higher animals (Metazoa) the expansion of this phase has gone so far that the simple-celled stage has been completely suppressed, and in consequence their life history is as free from alternating phases as that of the lower plants, though for a very different reason. The lower groups show no expansion of the fertilized egg. The higher animals consist of nothing else.[c]

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[a] It is clear that the expansion of the fertilized egg could occur in siphonaceous algæ and fungi without any cross walls forming between the nuclei as they arise by subdivision. The mature thallus of an Acetabularia is obviously the enormously expanded syngamete and may or may not contain double nuclei. On the other hand, the Infusoria may be found to consist of one double cell, the successive cell generations not adhering to form a tissue.

[b] Hofmeister, W., Vergleichende Untersuchungen der Keimung, Entfaltung und Fruchtbildung höherer Kryptogamen und der Samenbildung der Coniferen. Leipzig. 1851.

[c] This fact is obscured, but not negated, by the splitting up during chromosome reduction of the egg and sperm mother cells of animals into four gametes, which are simple cells, but which are no longer capable of further development unless they conjugate. As previously noted (p. 13, footnote *a*), these two cell generations occurring during chromosome reduction constitute a transition stage between the old and the new generations and can not properly be classed with the simple-celled phase.

The occurrence of alternating phases in the life history of an organism indicates that it is in an unstable evolutionary condition, since it has not yet attained the

That there are two unicellular stages in the life history of an organism should not be allowed to introduce any confusing technicalities. For genealogical purposes the spore is quite as much the descendant of the antherozoid and the egg cell as it would be if the other tissues of the sporophyte had not been intercalated. From chromosome reduction to chromosome reduction, from spore to spore, or from egg to egg is one generation, and not two. The prothallus is no more mysterious than any other piece of ancient history. The ferns were originally liverworts, the capsules of which had the good fortune to get roots into the ground and keep on growing, but they have not yet learned to dispense with their first vain attempt at building a structure on a simple-celled basis.

SEXUALITY A MECHANISM OF EVOLUTION.

Stress has also been laid upon this supposed alternation of "sexual" and "asexual" generations in the belief that a clew was here to be gained regarding the nature of sex and of attendant "mechanisms of heredity." But since only one generation is really involved instead of two, and since the phase of existence which has been termed asexual is in reality the more strongly sexual, it is not surprising that these expectations have not been realized. Sexuality facilitates interbreeding and makes it the more effective by distributing new variations throughout the species; it is, in short, a mechanism of diversification and of evolution, a fundamental and universal fact which stands squarely in the way of the alleged law of heredity under which organisms would breed true and be exactly alike. This notion of a uniform and unchanging heredity,[a] or of any natural tendency to such a condition of organic

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most effective type of organization. The persistence of a clearly two-phased condition in the vascular cryptogams and of a reduced alternation of phases, even in the highest algæ and flowering plants, is a proof of the extreme slowness of the evolutionary progress of the plant kingdom. Animals seem to have passed through the diphase period of their existence before the dawn of geologic history, and appear in the oldest fossil-bearing strata, not only as completely double-celled organisms but highly differentiated ones at that. Not only are there no traces of the two-phased progenitors which must have gone before the lowest known fossil organisms, but up to now zoologists have not realized the need of postulating such forms at all, and have been content to derive the higher animals from merely simpler but always completely double-celled ancestors, which, of course, are not primitive. It seems not improbable that the completely double-celled condition has been reached independently by different groups of higher animals, just as it has been approximated, though not attained, by the Fucaceæ and the phanerogams among plants. The animal kingdom does not contain, so far as is now known, a single species that shows alternating phases in its life history; it has no counterparts of all that wealth of forms which in the plant kingdom bridge the interval from the protophytes to the flowering plants.

[a] "The modifications introduced into palingenesis by kenogenesis are vitiations, strange, meaningless additions to the original, true course of evolution."—*Haeckel, Evolution of Man, vol. 11, p. 460, note 9.*

stagnation, can well be relegated to the limbo of hypotheses which have not proved useful. Heredity is not a mechanism or a force; it is merely another name for the property of organic continuity or succession. There is no more heredity in an organism at one stage of its life history than at another.

Sexual and other diversities inside specific lines are not useless morphological complexities or mere failures in the execution of a fundamental plan of complete uniformity. Diversity, interbreeding, and evolution are physiological factors of the highest importance in maintaining vital efficiency.

Morphologically speaking, sexuality is a specialization of the internal diversity of the species, and among plants, at least, it has been attained independently in a large number of unrelated natural groups. There are grades of sexual differentiation just as there are of organic structures. Moss plants and fern prothalli may be sexually differentiated and the differentiation may occur farther back in the spore itself, or even in the sporophyte or double-celled phase, as in the flowering plants and the higher animals. Thus in the same species there may be two sexualities, one in the simple-celled stage and another in the double, and these may have no homology or causal connection, except as they both serve the same purpose of promoting more efficient symbasis. Indeed, the sexuality of the highest types of organization is not merely double, but threefold; the individual has sex, as a whole; the double cells of which the body is composed are a part of a sexual process, and the simple cells which it produces for the initiation of a new generation are sexually differentiated.

TWO TYPES OF DOUBLE-CELLED STRUCTURES.

That organisms are everywhere associated in species is not because of some undiscovered principle or mechanism of heredity; it is simply because the interweaving of the lines of individual descent is being maintained, without which the specific association would be dissolved into indefinite radial divergence and degeneration, as among the varieties of bananas and other plants long propagated from cuttings. Many explanations have been conjectured for the supposed absence of sexual reproduction among the higher groups of fungi. From the standpoint of a symbasic evolution, however, it becomes evident that the existence of true, coherent species among these fungi is a sufficient evidence of interbreeding, and hence of sexuality. There is in many groups a deficiency of specialized sexual organs, but these are rendered unnecessary by abundant opportunities for direct conjugation among the mycelial filaments.

That the cells of the more complex reproductive tissues of the higher fungi are known to have two nuclei, while in the younger mycelium

there is only one, might also have been accepted as proving that conjugation had taken place. This does not mean, of course, that cross-fertilization is indispensable for spore production among the fungi, but their habits of growth certainly give many opportunities for conjugations between mycelia of different descent, by which the existence of compact and well-defined species can be maintained, although the peculiar structure of fungous tissues permits extreme variability of the size and external form of the fruiting bodies.

In structural complexity, size, longevity, and other measures of organic efficiency the binucleate fungi have an intermediate position in the plant series. Their wide distribution and extensive differentiation into species, families, and orders are evidences of ample opportunities in time and environment, so that it is not unfair to explain their evolutionary limitations by reference to their peculiar type of organic structure.

Sexual reproduction is accomplished through conjugation or fusion of cells, a process which may be divided into three stages: (1) Plasmapsis, the fusion of the cytoplasm or unspecialized protoplasm; (2) karyapsis,[a] the fusion of the nuclei or nuclear protoplasm; (3) synapsis, the fusion of the chromatin. The binucleate cells of the fungi may be said to have passed the stage of plasmapsis, but karyapsis, or true fecundation, like that of the higher plants and animals, has not taken place.

For the form of sexuality which produces the binucleate cell structures of the higher fungi the name *apaylogamy* is proposed, in allusion to the fact that the two nuclei have not yet associated. The higher stage, where the nuclei fuse but the chromosomes remain apart, may be called *paragamy*, which implies that the union is still incomplete, but that a more intimate relation has been established. These two double-celled conditions may be further contrasted with *haplogamy*, the primitive method of undeferred combination of the sexual cells, nuclei, and chromatin.

To the "asexual generation," which is not asexual and not a generation, the term *paragamic phase* may be applied among the higher plants and animals, the tissues of which are composed of cells with a

[a] The etymology of these terms will be obvious to all students of biology, *plasma* and *karyon* being the familiar Greek renderings of protoplasm and nucleus, respectively. The other element, ἁψίς, signifies a binding or tying together and also a mesh or network, a meaning especially appropriate in view of the reticular structure of living matter.

The series might be completed more logically by using the distinctive word *mitapsis* as a substitute for synapsis, which in its etymology is scarcely more than a Greek equivalent for the general term conjugation. Mitapsis is derived from μίτος, a thread, and alludes to the threadlike condition assumed by the chromatin during the process of chromatic fusion.

double number of chromosomes. The binucleate structures of the fungi may be referred to as the *apaylogamic phase*. The so-called "sexual generation" may be called the *haplogamic phase* in both cases. These new terms might not be necessary if words were used for descriptive purposes only, but in the present instance they have general implications too important to be disregarded.

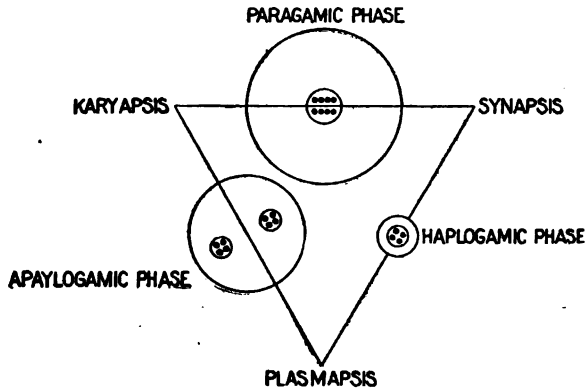

FIG. 1.—Diagram showing the different types of cell structures and their position in the life history of organisms.

Haplogamic structures are built between synapsis and plasmapsis, apaylogamic between plasmapsis and karyapsis, paragamic between karyapsis and synapsis. Between the three critical points of cytological activity there are three intervals, in which the organism can pause to gain additional size or numbers by vegetative division of cells. The relations between the cell structures and the nuclear processes are illustrated by the accompanying diagram (fig. 1).

No organisms have, however, structures built in all the three phases. The relative importance of each phase in the life histories of the different natural groups can also be illustrated by simple diagrams, as shown in figure 2.

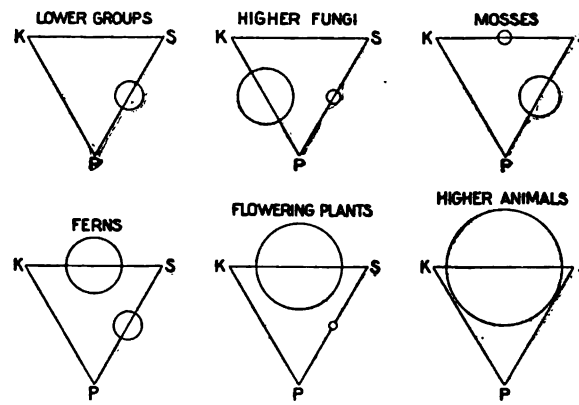

FIG. 2.—Diagram showing the relative importance of the paragamic, apaylogamic, and haplogamic phases in the life history of various groups of organisms.

The relative importance of the different phases in the life history of the various groups of organisms can be represented in another way, as is shown on Plate I. The diagrams on this plate show in addition a network of descent in its simplest form, composed of successive generations linked together at the first stage of conjugation. The generations themselves are seen to be composed of alternating

simple and double celled phases in organisms of intermediate evolutionary rank, and finally the double-celled phase is shown to be an expansion of the fertilized egg, which constitutes an increasingly large part of the life history as organisms mount higher in the scale of evolutionary progress.

It is thus easy to understand why the two types of double-celled structures have very unequal possibilities of organization. Two nuclei are evidently better than one, but their association is too slight, apparently, to gain much of the vital stimulus consequent upon the more effective method of conjugation followed by the higher plants, where the chromosomes of two fused nuclei lie in juxtaposition in the new nucleus. The higher organisms have not merely double cells, but, what seems to be vastly more important, compound nuclei, a more advanced and energized stage of the sexual process, which enables them to maintain for exceedingly long periods of time the power of growth and subdivision.[a]

The intercalation of the double-celled structure does not change the order of nuclear events in cross-fertilization, but it may be said to change fundamentally their chronological and physiological relations. The true historical sequence of conjugation is plasmapsis, karyapsis, and synapsis, but the apparent and practical sequence in the higher plants and animals becomes synapsis, plasmapsis, and karyapsis, the synapsis which ends one conjugation being followed closely by the plasmapsis which begins another. The suspension of nuclear changes for vegetative growth no longer occurs between synapsis and plasmapsis, but between karyapsis and synapsis, the double-celled, paragamic structure being built, as already stated, on a new and highly sexual plane, that is, out of cells in a state of prolonged sexual union.

If, as may be supposed, the benefit of synapsis lies in the making of new associations of the ancestral chromatin elements, it is obvious that the bringing of two such newly energized nuclei together would produce a condition which, for want of other words, might be called a multiple vital tension. The double-celled type of structure involves, therefore, not merely a transfer of emphasis to a new part of the life-cycle, but a new and improved sexual process, which raises the biological equation to a higher power. From this standpoint it is obvious that the morphological diversities of sex have a fundamentally important and truly physiological function in building up and maintaining the efficiency of the complex organization of the higher plants and animals. It is as illogical to ascribe the internal diversity of

[a]As noted before, some organisms, such as Caulerpa and Acetabularia, show a considerable degree of evolutionary progress, and have not as a matter of fact attained the cellular type of organization at all; they may, however, be found to have double nuclei and to be very striking examples of the expansion of the fertilized egg.

species to external environmental causes as to arbitrary mechanisms of heredity.

The extent to which the static concept of a normally unchanging heredity has obscured evolutionary thought and investigation could not be better shown, perhaps, than by the fact that, notwithstanding the great multiplicity of terms which have been proposed for all the imagined kinds of variations, no name has been suggested for this normal and necessary intraspecific diversity. The deficiency may be made good by the use of the word *heterism* for the whole group of phenomena, ranging from mere individual diversity to the highest specializations of heterism, exemplified by sexes, castes, and polymorphic conditions. It is true that the members of a species look alike when compared with those of other species, and there may be no harm in ascribing this likeness to heredity, but there is nothing to show that this heredity of general resemblance has anything to do with evolution except as an incidental result. Evolution does not take place between species, but inside of them; it is not an *inter*specific phenomenon, but *intra*specific. Its principal factors are heterism and symbasis, not heredity and environment, as believed by the selectionists, nor heredity and segregation, as supposed by the mutationists.

HEREDITY IN RETICULAR DESCENT.

The greater efficiency of the double nuclei is, however, only one more evidence of the importance of sex as a means of diversity and of bringing diverse protoplasms together. The nuclear network of chromatin which controls the activities of the cell corresponds to the network of descent through which the cell has come into existence. Symbasis, or diversity of descent with normal interbreeding, is the foundation of the strength and vitality of the organism, because it increases the efficiency of the nuclei of the component cells.

Inbreeding or defective fertilization, on the other hand, would cause nuclear deterioration, as so strikingly shown by Maupas in the so-called senile degeneration of ciliate Infusoria induced by keeping them too long without cross-fertilization. This phenomenon is, indeed, closely parallel to senile degeneration, but there is, nevertheless, an important difference. In true senile degeneration the vigor of the cells is declining because of the absence or long postponement of conjugation. In monobasic degeneration, conjugation may take place, but is not effective because of insufficient diversity of descent. Monobasis is the antithesis of symbasis; it means descent without cross-fertilization, on single or very narrow lines. The inevitable result is degeneration, with a rapidity proportional to the closeness of the inbreeding and the complexity of the organisms.

This intimate relation between organic descent and organic structure enables us to understand the phenomena of organic succession without

resorting to abstract principles or to hypothetical mechanisms of heredity. The network of descent is, as it were, a map showing the alternative routes of the developing organism, and permitting normally any combination of ancestral characters, as may well result from the endlessly varying arrangements into which the ancestral chromatin elements may fall at the time of synapsis or chromatic fusion. Twins developed from the same ovum would have the same arrangement of chromatin, which accords with their close similarity of form, but otherwise there is unlimited diversity, even among the simultaneous offspring of the same parents. It would seem, therefore, that instead of a mechanism of heredity inside the reproductive cells there is an automatic device for insuring diversity. The higher the organization the more complex the descent, and the greater the variety of nuclear configurations and the resulting individual diversity.

Nevertheless, inheritance is not governed merely by chance, nor limited even to the infinity of nuclear networks to be made by the combinations possible among the ancestral chromatin elements. With the greater vitality of interbred organisms is associated also a stronger heredity or prepotency of the wild or more broadly symbasic types when such are crossed with inbred domesticated varieties. New variations, too, appear to have the same effect as diversity of descent in lending greater vigor and prepotency. Even mutations, or degenerative variations induced by inbreeding, are prepotent on their own plane of symbasis—that is, when crossed only with their own inbred relatives—though they are promptly obliterated or "swamped" when brought into contact with the broadly symbasic wild type, the prepotency of the diverse descent being far greater than that attaching to the inbred variation. It is the prepotency of variations which renders evolution truly kinetic; for the methods of organic descent are such as to bring about a spontaneous change of type. The environment often influences the direction of this vital motion, but is in no proper sense an actuating cause.[a]

Cells are the units of organization, but species, as groups of interbreeding individuals, are the units of evolution. The causes of evolution are not revealed by hypothetical subdivisions of cells into character units or determinate elements, but by ascertaining the methods of descent through which interbreeding maintains organic strength and evolutionary progress. Cells divide themselves, as we know, into other cells, and species into other species, but it is only as cells and as species that their vital, organic, evolutionary activities are accomplished. *Individuals* vary and mutate, but only *species* evolve. To classify the various stages and functions of organisms under general and abstract terms may be desirable, but for evolutionary purposes it

[a] Cook, O. F. Natural Selection in Kinetic Evolution, Science, n. s., 19: 549. 1904.

is the network of descent which represents the concrete, significant fact, and it is this which can be resolved, if necessary, into its component lines, polygons, or nodes, to furnish units for the calculation of quantitative effects of inheritance, as in Galton's Law of Ancestral Resemblances and Filial Regression, under conditions of normal symbasic descent, or in Mendel's Laws of Disjunction, in hybrids of abnormally inbred varieties.

The recognition of the double character of the cells of the higher plants and animals permits many other phenomena of inheritance to be understood, though it seems to take us farther than ever from the hope of a merely mechanical explanation of the nature of heredity itself. If conjugation were concluded immediately, the well-known phenomena of sterile hybrids would be impossible, the sterility which puts an end to their existence being due, as now known, to the failure to perform synapsis or chromatin fusion. On the other hand, it may be that crosses between narrowly inbred varieties sometimes have the power of passing by the period of synapsis without a true fusion of the parental chromatin, perhaps in a manner corresponding to that in which Thalictrum produces seeds parthenogenetically, by avoiding chromosome reduction. The germ-cells might have a preponderance of chromatin from one parent or the other, or might even be quite unmixed, as claimed for Mendelian hybrids. It is obvious, however, that to explain Mendelism in this manner is to admit the essential abnormality of the phenomenon.

SUMMARY.

It has been held self-evident that there can be nothing in evolution except heredity and environment, and it was a simple deduction from such an aphorism that differences must all be due to environment, since "heredity would, if nothing interfered, keep the descendants perfectly true to the physical characters of their progenitors." Such heredity, however, is a pure figment of the scientific imagination; it is a hypothesis which lends us no aid in understanding the facts of organic succession. A stereotyped heredity could make nothing new; the interbreeding of diverse individuals and the prepotency of new variations are the constructive factors, not heredity and environment.

Symbasis is the method, interbreeding the means, and sexuality the mechanism whereby organic evolution has been accomplished; these are the concrete and efficient causes of the vital motion of species. The association of organisms into species of similar individuals is not brought about by a predetermining hereditary mechanism, but by symbasic interbreeding. The highest organization has not been attained in "asexual generations," but in structures completely and essentially sexual, built wholly of conjugating cells. There has been

no evolution away from sexuality. Long-continued violations of the law of symbasis bring only degeneration.

This interpretation of evolutionary facts opens the way to an adequate physiological explanation of the significance of sex, and affords also a working theory of the chief cytological complications that have arisen as a consequence of sex—complications that have hitherto rendered obscure the nature of the cell-bodies of higher animals and plants.

The external diversity of organic nature and the internal diversity of cells and of reproductive processes take on new and unexpected significance. Both are shown to be consequences of sexual specialization, without which no evolutionary advance beyond simple-cell colonies has been possible. More than this, gradations in the perfections of the higher double-celled structure are correlated with definite stages of evolutionary progress, so that from the structure of an organism its kind of sexuality can be deduced. Evolution becomes, in the new view, a physiological rather than a morphological process, since the methods of descent affect the quality and efficiency of the organism even more promptly and fundamentally than they do its external form.

PLATE.

EXPLANATION OF PLATE.

The circles (○), eights (8), and thetas (Θ) represent in each case the nucleus or nuclei belonging to a cell, and the succession of cell generations is shown by a string of nuclei either simple, in pairs (apaylogamic double cells), or fused (paragamic double cells). The half circles (⌓ ⌔) and quadrants (◸ ◺) represent the two cell generations formed during chromosome reduction. The brackets [ ] represent a cell at the period or periods when the organism is reduced to a unicellular condition. All the signs for nuclei could be supposed to be inclosed by a cell wall, which has been omitted for the sake of clearness. For the same reason only the cell lineage leading directly up to the formation of the gametes has been shown, and no account has been taken of the enormous multiplication of cells which occurs not only to build up the bodies of animals and plants but also to form many gametes. Only a few of the numerous cell generations which make up the organisms in question are shown.

EXPLANATION OF SIGNS.

P — Plasmapsis—fusion of the cytoplasm, or unspecialized protoplasm.

K — Karyapsis—fusion of the nuclei, or nuclear protoplasm.

Ⓢ — Synapsis—fusion of the chromatin elements.

Heterotypic and homotypic divisions following synapsis.

○○○○ — Nuclei of haplogamic phase—structures composed of simple cells having nuclei and chromatin elements completely fused.

Nuclei of apaylogamic phase—structures composed of double cells, each having two unfused nuclei.

ΘΘΘ — Nuclei of paragamic phase—structures composed of double cells having single nuclei containing unfused chromosomes.

[ ] — Cell, at periods where the organism is reduced to a single cell.

The expanded egg.

EXPLANATION OF FIGURES.

FIG. 1.—Lower organism, such as Sphæroplea, having only simple-celled (haplogamic) tissues. The fertilized egg undergoes no development beyond merely splitting up into four spores when it germinates.

FIG. 2.—Higher fungus, such as Agaricus or Puccinia, showing alternation of simple-celled and double-celled phases, the latter apaylogamic, i. e., with two unfused parental nuclei in each cell. The fertilized egg has expanded into a mass of apaylogamic tissue.

FIG. 3.—Moss, showing alternation of a long simple-celled and a short double-celled phase, the latter paragamic, i. e., with parental nuclei fused but with their chromosomes still distinct and unfused. The fertilized egg has expanded slightly into a mass of paragamic tissue.

FIG. 4.—Fern, showing alternating phases as in moss (figure 3), but with a short simple-celled phase and a long double-celled phase, the paragamic phase having developed at the expense of the haplogamic. The fertilized egg has expanded very much into a mass of paragamic tissue.

FIG. 5.—Flowering plant (phanerogam), showing alternation of a very short simple-celled phase with a very long double-celled phase, the paragamic phase having developed greatly at the expense of the haplogamic. The egg mother-cell develops only one cell (macrospore). The fertilized egg expands into a large mass of paragamic tissue in which the greatly reduced haplogamic phase develops in a semiparasitic manner, it having no free existence.

FIG. 6.—Higher animal, having only double-celled tissues, the haplogamic phase having been completely suppressed by the greatly expanded paragamic phase. The egg mother-cell develops only one egg. The fertilized egg has expanded into a large mass of tissue.

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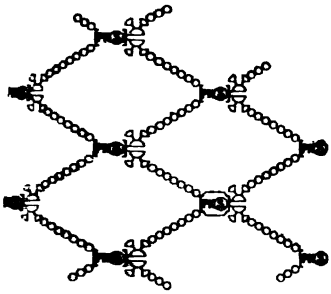

FIG. I.—LOWER ORGANISM.

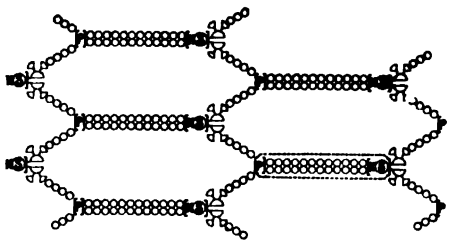

FIG. 2. HIGHER FUNGUS.

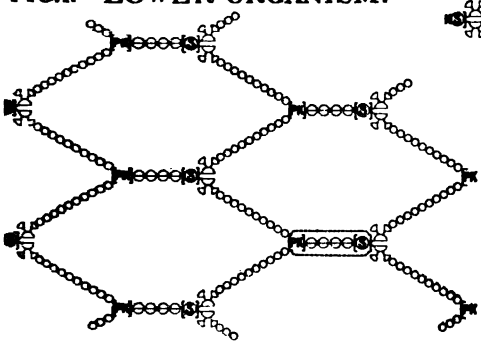

FIG. 3.—MOSS.

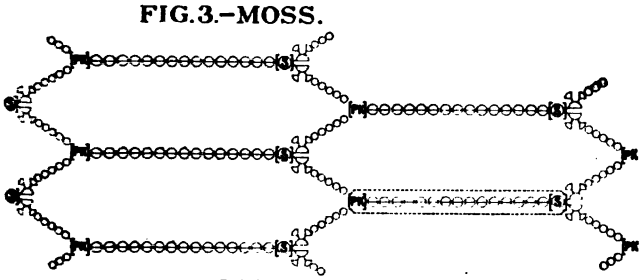

FIG. 4.—FERN.

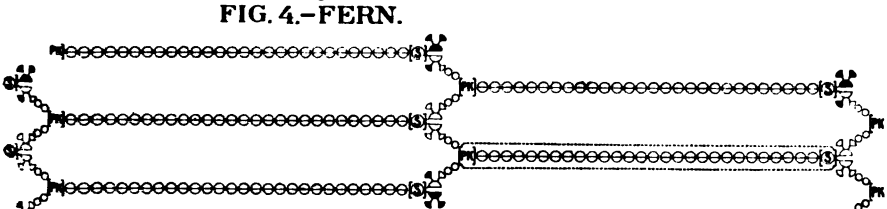

FIG. 5.—FLOWERING PLANT.

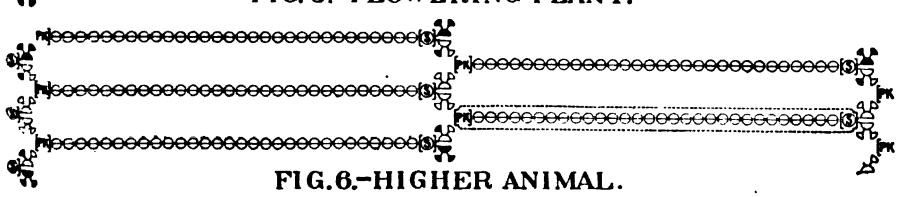

FIG. 6.—HIGHER ANIMAL.

DIAGRAM ILLUSTRATING THE NETWORK OF DESCENT, SUCCESSION OF GENERATIONS, ALTERNATING PHASES, AND EXPANSION OF THE FERTILIZED EGG.

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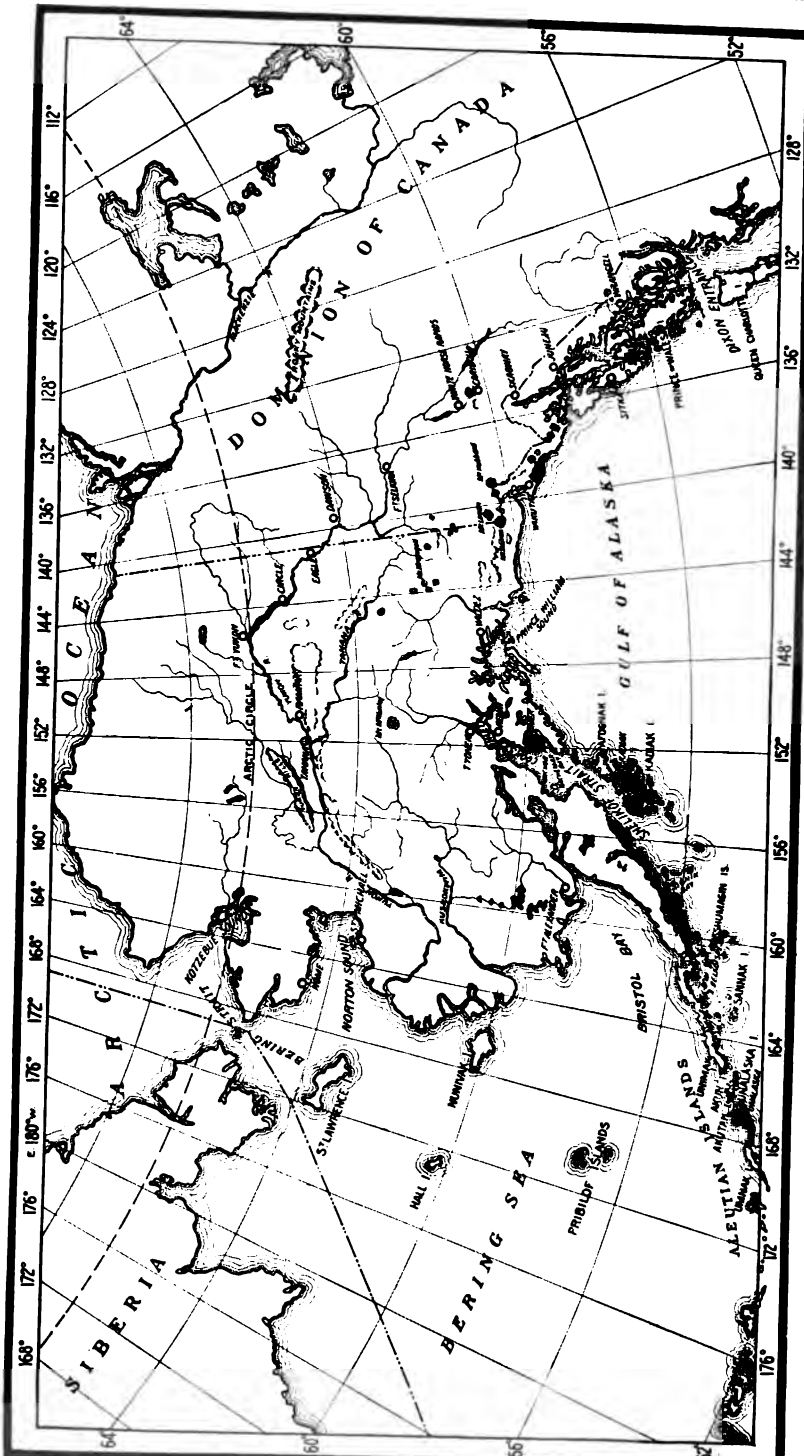

MAP OF ALASKA.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 82.

B. T. GALLOWAY, *Chief of Bureau.*

GRASS LANDS OF THE SOUTH ALASKA COAST.

BY

C. V. PIPER,

AGROSTOLOGIST IN CHARGE OF FORAGE PLANT INTRODUCTION.

GRASS AND FORAGE PLANT INVESTIGATIONS.

ISSUED AUGUST 22, 1905.

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1905.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., May 19, 1905.

SIR: I have the honor to transmit herewith a paper entitled "Grass Lands of the South Alaska Coast," and to recommend that it be published as Bulletin No. 82 of the series of this Bureau.

This paper was prepared by Mr. C. V. Piper, Agrostologist in Charge of Introduction of Grasses and Forage Plants, Grass and Forage Plant Investigations, and has been submitted by the Agrostologist with a view to publication.

The four plates accompanying the paper are necessary to a proper understanding of the text.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

PREFACE.

Since the discovery of gold in Alaska in 1897 continuous calls for information concerning the agricultural possibilities of the Alaska Peninsula have come to the Department of Agriculture. Much valuable information on this topic has been secured by the Office of Experiment Stations largely through the Alaska experiment stations at Sitka, Kenai, and Copper Center in charge of Prof. C. C. Georgeson, but as the work of these experiment stations was necessarily largely local in character, and as it was highly desirable to study conditions in sections remote from the stations, the Office of Experiment Stations requested the Bureau of Plant Industry to send some one to explore as large an area of the Alaskan country as might be feasible. Accordingly Prof. C. V. Piper, of the Office of Grass and Forage Plant Investigations, was detailed to make this exploration under the joint auspices of the Office of Experiment Stations and the Bureau of Plant Industry. The summer of 1904 was spent in this work. The area explored is shown in black on the map constituting Plate I. Many interesting facts relating to agricultural possibilities in the region covered were recorded, and Professor Piper discusses them in the following pages in detail.

For further information concerning the results of this exploration the reader is referred to the Annual Report of the Office of Experiment Stations for the year 1904.

W. J. Spillman, *Agrostologist.*

Office of Grass and Forage Plant Investigations,
Washington, D. C., April 14, 1905.

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GRASS LANDS OF THE SOUTH ALASKA COAST.

INTRODUCTION.

A glance at the accompanying map of Alaska (Pl. I) will show that the coast line beginning at Dixon Entrance, in longitude 132°, latitude 54° 30′, and extending to Unalaska, in longitude 166° and latitude 54°, is nearly in the form of a semicircle, or, rather, of a half ellipse, the east and west diameter of which would be about 2,000 miles and the north and south diameter about half this distance. Near the northernmost part of this coast line are two large inlets, the eastern one Prince William Sound, the western one Cook Inlet. It will be further noticed that islands are very numerous on the coast and that the coast line is much indented by narrow inlets or fiords, a fact better shown on larger maps. The principal places mentioned in this paper are likewise indicated on the map. Officially, the region from Mount Saint Elias eastward is known as southeastern Alaska, that west of this peak as southwestern Alaska. From an agricultural standpoint, however, there is a much better and very marked dividing line. From Cook Inlet eastward practically all of the lands lying near the coast are densely timbered up to an altitude of 2,000 to 3,000 feet. From Cook Inlet westward, excepting Afognak Island and a small portion of Kadiak Island, the lands are devoid of timber, and are for the most part grass covered.

The total area of the coast grass lands is about 10,000 square miles, nearly all of which lies between Cook Inlet and Unalaska, a distance of about 700 miles. At least one-half of this land would seem capable, in time at least, of profitable utilization. From various causes it has remained until now practically unused.

South Alaska is a mountainous country, a great range of snow-capped peaks on the mainland paralleling the entire coast. Eastward from Cook Inlet great numbers of glaciers arise in the higher mountains, and many of these rivers of ice extend downward to the sea. Westward from Cook Inlet no glaciers reach the sea, although many of the mountain peaks are from 5,000 to 8,000 feet high. This striking difference apparently depends on a much smaller annual rainfall and snowfall.

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In general the lands are hilly, sometimes rising abruptly from the seashore, but seldom too steep to afford a luxuriant grass covering. More often, however, the hills near the coast are low and rounded, with intervening valleys. In places there are wide areas contiguous to the coast of from 100 to 1,000 feet elevation and comparatively level. Most of the smaller islands, too, have comparatively gentle slopes, and either are under 1,000 feet elevation or have but few hills reaching above that height. The coast line everywhere is indented by numerous bays or inlets, into many of which rivers flow. At the heads of these bays there are, as a rule, considerable areas of flat or nearly flat lands. Such locations naturally afford the most advantageous sites for agricultural settlements, especially as these flat lands are exceedingly well grassed, and with little preliminary labor can be prepared for mowing.

Where the land is level it is very likely to be wet and covered with a growth of peat moss. Under such circumstances it supports but a scanty vegetation. Even on the hillsides this peat moss may become established, and where it does so the grasses quickly become less luxuriant. The decay of this moss and of other vegetation results in the formation of a humous soil, very retentive of moisture. So deep does this humus become that the real soil is often entirely concealed. Where it is possible to destroy this moss by burning, the result is always a heavy crop of grass or other plants. Most of the land that lies at less than 1,000 feet elevation is covered by a most luxuriant growth of native grasses. Over large areas these grasses are frequently 6 feet high, thus furnishing a large quantity of fodder. On the remaining areas, lying at higher elevations or on exposed slopes, the grasses are too short to cut for hay, but furnish splendid grazing.

That grass in Alaska is exceedingly abundant and fairly nutritious and that cattle will thrive upon it are facts beyond question. But these facts in themselves are not sufficient to enable a prospective settler thinking of engaging in stock raising to determine whether or not such a venture would be likely to prove profitable. The mere abundance of grass of fair quality is not sufficient to insure success in stock raising in an isolated region like that under consideration.

The following statements regarding the Alaska grass lands and the factors that have a bearing on their profitable utilization are based on as complete a survey as one season's work would permit, together with the facts previously recorded by reliable authorities. A detailed report of the conditions actually observed will appear in the Annual Report of the Office of Experiment Stations for 1904. The present bulletin designs rather to cite these facts in their bearing upon the south Alaska grass lands as a desirable field for stock raising.

THE LOCATION OF THE GRASS LANDS.

The accompanying map (Pl. I) indicates the general location of the southern Alaska areas which are covered with grasses. These areas differ considerably in detail and are here discussed separately.

KADIAK ISLAND.

Kadiak Island, which lies off the mouth of Cook Inlet, is about 100 miles long by 50 miles wide. It is mountainous in character, the hills rising more or less gently from near the seashore to heights of 1,000 to 3,000 feet. At the end of July, 1904, there was still considerable snow at 2,000 feet (Pl. IV), but this is said to be quite unusual. This island, like most of the Alaska coast, is much cut into by long, narrow bays, into most of which flow streams. The flat lands lying at the deltas of these streams are, as a rule, very heavily covered with grasses (Pl. II). The slopes also, up to an altitude of 1,500 feet, are well grassed, except where there are thickets of alder or willow; but these slopes are usually too steep to utilize otherwise than by grazing. The total area of these hillside lands is much greater than that of the approximately level stretches, in the proportion of at least 20 to 1.

On the hillsides the principal grass is bluetop (*Calamagrostis langsdorfii*), which often covers large areas in a pure growth. This was exceedingly fine on hillsides burned over in March, by which means the old straw and moss were destroyed, thus permitting better drainage and making the soil warmer. In such places this grass is often 6 feet high. On the contrary, if the hills are burned over in June the fire is likely to kill the grass roots as well as the moss, with the result that fireweed usually takes possession of the ground.

Other grasses than bluetop on the hillsides are relatively unimportant, though sometimes considerable areas of Siberian fescue occur, and on the higher slopes are a number of low grasses of forage value.

On the flat lands before mentioned the tall beach sedge (*Carex cryptocarpa*) forms a broad fringe along the shores of the bays and sloughs, especially on lands which are occasionally covered by tide water. Back of this sedge, beach rye (*Elymus mollis*) forms a more or less broad zone, often mixed with patches of a coarse bluegrass (*Poa glumaris*). In the still drier portions bluetop occupies the ground almost exclusively. The three plants mentioned furnish the great bulk of forage on Kadiak Island, and indeed on most parts of the Alaskan coast, but the bluetop is more abundant than all of the other grasses combined.

Bluetop has slender stems and thin leaves, thus curing very readily and making a sweet and palatable hay. Beach rye, on the contrary,

has thick stems and thick leaves, in consequence of which it cures slowly. Beach sedge has a three-sided, solid, pithy stem, and is therefore very difficult to dry. All three of these plants grow so luxuriantly that they often yield 3 tons of hay or more per acre.

Of forage plants other than grasses the lupine and fireweed, hereafter described, are both abundant. In a green state they are readily eaten by sheep, but cattle prefer the grasses.

In portions of the island which have been more or less closely grazed for some years it was noticeable that the taller wild grasses had largely disappeared, being replaced principally by bluegrass (*Poa pratensis*) and wild barley (*Hordeum boreale*). Cattle seem to be much more fond of the former than of the latter grass, although in parts of northern Europe the wild barley is considered a most excellent grass.

All of Kadiak Island, except a small portion in the extreme northeast, is practically timberless, as are most of the adjacent islands. In the valleys, however, there is usually a small number of cottonwoods and willows, and on wet slopes scrub willows and alders form dense thickets. Afognak Island, however, which lies northeast of Kadiak, is quite densely covered with spruce.

ALASKA PENINSULA AND ADJACENT ISLANDS.

The whole region to the west of Kadiak Island might briefly be described as similar to that island, but entirely deviod of timber, the shrubs being more scrubby and the grasses less luxuriant. The peninsula itself is very mountainous, and for considerable stretches along the coast the hills rise abruptly from the water's edge. In the bays and inlets, however, there are frequently considerable areas of comparatively level lands well grassed, though seldom as luxuriantly covered as those before mentioned. The islands lying off the coast are comparatively low, and some of them are said to be exceedingly well adapted to stock raising. Such areas as were examined indicate that in general there is a greater variety of forage grasses than to the eastward, but most of them are smaller in size.

At the present time there is a mail steamer plying once a month between Valdez and Unalaska. This boat carries the mail, and stops at such points as business demands. The population of this entire region is exceedingly sparse, and many of the outlying islands would probably have to be reached by means of sailing craft.

UNALASKA AND THE NEIGHBORING ISLANDS.

Unalaska and the neighboring islands differ on the whole comparatively little from Kadiak Island, though the vegetation as a rule is

decidedly less luxuriant. The grasses are much the same in kind, although differing in their relative abundance. Some difficulty would be experienced on these islands in finding sufficient tall grass to furnish winter fodder in case large quantities were necessary, though in some of the more sheltered valleys small areas were observed where the grasses were very tall. There is quite a herd of cattle at Unalaska which, according to local reports, receive but very slight attention during the winter, only a small quantity of feed being cut for them. The principal advantage of Unalaska and the neighboring islands would seem to lie in the fact that they are on the line of travel of the vessels going to the Yukon and to Nome. If sufficient numbers of cattle were raised on these islands, doubtless little difficulty would be experienced in finding a market for them at the above-mentioned points. Indeed, a Seattle company, which purposes, among other things, to engage in cattle raising primarily for these northern markets, has already begun operations on Akun Island.

KENAI PENINSULA.

Kenai is the name given to the large peninsula lying between Cook Inlet and the Gulf of Alaska. That portion of it on the east side of Cook Inlet and north of Kachemak Bay, comprising an area 100 miles long by 20 to 30 miles wide, is an extensive plateau. Its southern portion, on Kachemak Bay, lies 500 to 1,000 feet or more above the sea level. It slopes mainly to the westward, so that that part from Anchor Point northward is but 100 to 200 feet above the sea level. Most of this land is timbered with spruce, but there are considerable areas of grass near Anchor Point, near Homer, and on the north side of Kachemak Bay.

At Homer there is an extensive sand spit, about 4 miles in length and from one-fourth to 1 mile across, which supports a good growth of several grasses and sedges. Beach rye is the most important and most abundant, but red fescue, bluegrass, and seashore grass furnish considerable grazing. At the base of the spit the land rises gradually to the high plateau above, the scattered timber giving the appearance of mountain parks. The open portions of this land support a luxuriant growth of bluetop, often 6 feet tall. At a rough estimate the open grass lands in this vicinity comprise about 2,000 acres.

The site of a proposed Finnish colony is on the north side of Kachemak Bay, not far from its head. From the colony site to the head of the bay are extensive tide flats, which are mainly covered with sedges about 2 feet high. The marshy nature of these lands, together with the coarse nature of the forage, makes them of but limited value. Undoubtedly they can be much improved by diking.

The grass lands of the colony site proper consist of about 500 acres of excellent land, covered with a luxuriant growth of bluetop. These lands lie close to the seashore and less than 100 feet above it. Back of these lands are hills 500 to 1,500 feet high, the plateau on the top of which consists in part of extensive grass areas. Much of this grass is bluetop, often 6 feet high. Other areas are pure growths of Siberian fescue. Interspersed with these are several other good grasses, but none of them in great quantity. These plateau grass lands are apparently very extensive. To render them accessible will, however, require the building of roads or trails up to the easiest slopes. At Anchor Point there is but little grass land near the seashore, but on the plateau behind are considerable areas much like those just described. The plateau at this point is, however, much lower.

An important circumstance in relation to all of the grass lands of this region lies in the fact that they are underlaid with coal, which is exposed for miles in the bluffs along the coast. In view of this fact it is doubtful if title to the land can be gained by homesteading it.

At Kenai there are no naturally grassed lands, except the sand dunes along the beach and the marshes lying inside of them. The dunes are covered principally with beach rye and bighead sedge (*Carex macrocephala*). In the brackish marshes red fescue and seashore grass are plentiful. Here also is found poison parsnip (*Cicuta douglasii*) in small marshes, and there is a record of some native cows having been killed by it several years ago.

THE YAKUTAT PLAINS.

The only extensive areas of grass lands known in southeastern Alaska are those lying in the river valleys near the coast south of Yakutat. Inasmuch as these lands have been several times referred to in reports, and as they are now in part accessible owing to the building of the Yakutat and Southern Railway, a careful examination was made of them. The above-mentioned railway has been built primarily to reach the several rich salmon streams flowing into the ocean south of Yakutat, it being impracticable to fish them by approach from the ocean. This railway is projected to be built to the Alsek River, a distance of 45 miles. At present it is built only to the Setuck River, 10 miles from Yakutat.

Practically the whole of this region is an old glacial moraine, composed of fine gravel, which slopes very gently to the seashore. The land close to the seashore is somewhat higher than that lying behind, and is heavily timbered. Owing to this strip of higher land most of the streams flow parallel to the coast for some distance near their debouchments. It is along the valleys of these streams that the grass

lands lie, but owing to the flatness of the land and the slight elevation above the sea level they are very ill-drained, notwithstanding the gravelly nature of the soil.

Traveling along these rivers in a canoe one receives the impression that the grass is tall and rank on these flat lands. This, in fact, is the case on a very narrow strip just along the river banks, where there is a fine growth of bluetop (*Calamagrostis langsdorfii*) and sedge (*Carex sitchensis* Presc.). This strip of tall grass is, however, nearly always confined to the immediate banks of the rivers. The great mass of the land is covered with a thin layer of bog moss, which supports but a scant vegetation of grass and sedges less than a foot high.

It is a conservative statement to say that fully 80 per cent of these Yakutat grass lands are thus scantily grassed. Apart from this scant amount of grass, which practically precludes the cutting of winter forage, another serious difficulty presents itself in the fact that poison parsnip (*Cicuta douglasii*) occurs quite plentifully over all the land that is the least boggy, which, as before stated, is 80 per cent of the area. Thus, even if these meadows were used only for grazing, great care would need to be exercised in the spring, when grass is scanty and the sweet but very poisonous tubers of this plant are frequently forced to the surface by the frost.

While the above statements are true concerning the Yakutat meadows as a whole, there are small areas which are exceptional. For example, along the lower Ankow River occurs a narrow strip of several hundred acres well grassed with silver-top (*Deschampsia cæspitosa*) and beach rye (*Elymus mollis*) and free from Cicuta. Care would need to be exercised in utilizing even this, as the surrounding boggy lands bear an abundance of poison parsnip.

Again, the strip of land lying just within the ocean dunes is often well grassed with beach rye and red fescue (*Festuca rubra*).

A particularly good area of arable land lies along the railway where it reaches the Setuck River. This consists of 3 or 4 square miles of gravelly, well-drained, level land, at present looking much like a worn-out meadow. It is apparently very well adapted to such cultivated grasses as smooth brome-grass and tall meadow oat-grass. It will undoubtedly grow all sorts of hardy vegetables. The present grass covering is rather scanty, but it is probable that this can be greatly increased by cultivation. This particular piece of land is well worthy of the attention of homesteaders.

It is within the bounds of possibility that the larger part of the Yakutat plain can be drained and made into fine meadow lands. In its present state, however, this land is not adapted to stock raising, with the exception of such small areas as above noted.

IMPORTANT FACTORS RELATING TO THE AGRICULTURAL VALUE OF THE GRASS LANDS.

In determining whether or not the grass lands previously described offer a desirable field for settlement, a number of factors that bear more or less directly upon the problem need consideration. These factors may be discussed in the following sequence:

(1) The abundance and permanence of the feeds available.
(2) The possibility of raising forage on cultivated lands.
(3) The known facts in regard to live-stock raising.
(4) The available markets.
(5) Transportation facilities and freight rates.
(6) The desirability of south Alaska as a home.
(7) The choice of a location

THE ABUNDANCE AND PERMANENCE OF NATIVE FODDER PLANTS.

Live-stock husbandry in Alaska will have to depend primarily upon the native plants, supplemented in time, perhaps, by such additional ones as experiments shall indicate may compete with the native plants, or which upon cultivated land will yield heavily enough to be profitable. The most important and abundant of the native forage plants are as follows:

Bluetop.—Bluetop (*Calamagrostis langsdorfii*) is by far the most plentiful tall grass in Alaska, growing along the whole coast. On Kadiak Island and the Kenai Peninsula it is especially abundant, often being 6 feet high and very dense (Pl. III). It grows with special luxuriance on hillsides that have been burned over early in the spring. This burning destroys the moss, and thus makes the soil better drained and warmer. Bluetop also flourishes on the level boggy lands, but prefers a well-drained soil. Owing to its thin stems and leaves it cures very readily, and is therefore the usual hay grass of Alaska. It is often called redtop, but this name should be restricted to the true redtop, a very different grass.

There are no accurate data bearing on the point as to how well this grass will withstand continued cutting, but the general belief is that it rapidly becomes thinner in stand. It is noticeable about villages where cows are kept that the bluetop is scarce, being replaced by other grasses, especially bluegrass and wild barley. The area of bluetop is so great, however, that in many places it would be quite practicable to manage so as not to cut the same plats two years in succession, which practice would probably maintain the density of the stand.

Beach rye.—Along all the quiet shores and inlets of Alaska, wherever there is low land near the beach, there is a strip of beach rye (*Elymus mollis*) occurring just above high-tide level. Some-

times this strip is only a few feet wide, but on the low level lands near the heads of fiords there are often large areas of it 3 to 5 feet high (Pl. II, fig. 2). One patch of it examined had been cut the year previous, and on this the stand was scarcely half as dense as on neighboring pieces which had not been cut. This observation accords with the experience of others.

Where sand dunes occur on the coast, as at Kenai and near Yakutat, beach rye is an important sand binder. In such locations it is often very different in appearance from that found in other situations, the heads being short and thick. This is the result of infestation by a parasitic worm.

Bluegrass.—The true Kentucky bluegrass (*Poa pratensis*) is common all along the Alaska coast, where it thrives to perfection. It shows a tendency to occupy the ground where closely grazed, and cattle exhibit a marked preference for it. Several closely allied species also occur, and it is an important fact that they persist and increase where other grasses disappear, which seems to insure the permanence of pasturage of a high quality.

Silver-top.—The very nutritious grasses known as silver-top (*Deschampsia cæspitosa* and *D. bottnica*) occur in some abundance, especially in gravelly soils, whether on the hillsides or near the seashore. Owing to their stems being nearly leafless they yield but little hay, but the numerous fine basal leaves furnish most excellent forage.

Siberian fescue.—Siberian fescue (*Festuca altaica*) makes large tussocks, especially in gravelly soil and in open timber up to 1,000 feet elevation. In such locations it often makes a nearly pure growth It seems to be fully as nutritious as the well-known sheep fescue, but is a much larger grass.

Sedges.—Two tall species of sedge, *Carex cryptocarpa* and *C. sitchensis*, in places make dense stands 3 feet high or more, especially in wet soil; in the case of the former, more especially in tidal marshes. Considerable quantities of this sedge were cut for hay near Kadiak, and it is said to furnish excellent feed. These sedges are both quite smooth and soft, unlike most others.

Alaska lupine.—The blue-flowered plant known as Alaska lupine (*Lupinus unalaschensis*) is quite tall, often 3 feet high, and sometimes occupies large areas almost to the exclusion of other plants. It is thick leaved and rather fleshy, and is the only leguminous plant that is really abundant in Alaska. Sheep eat it readily. Should it prove palatable as well as nutritious to cattle the problem of a good winter ration for milch cows would be considerably simplified. Experiments with it as silage, both pure and mixed with grass, are much to be desired.

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With the exception of this plant the only legumes of forage value in the grass regions are two species of wild pea, both of which, unfortunately, are rather scarce.

Fireweed.—The well-known plant called fireweed (*Epilobium angustifolium*) often occupies the ground to the exclusion of others, especially where the land has been burned over in summer and the grass roots thus destroyed. Sheep seem fond of it. It is possible that this plant may prove profitable as silage, at least when mixed with grasses, but no tests with this end in view seem to have been made. Its great abundance at times makes such a test desirable.

There are three possible ways of preserving the above-mentioned plants for winter feed. The more easily dried—as bluetop and bluegrass—may be made into hay. Continued sunshiny weather on the Alaska coast is not to be depended upon, so that haymaking is accomplished only with much uncertainty. Where one needs but a small amount of fodder, little difficulty is experienced in selecting the few necessary sunshiny days. Where, on the contrary, one needs great quantities of winter feed, haymaking is impracticable. Resort in such cases must be had either to brown hay or to silage. Brown hay is simply half-cured hay, made by stacking the grass green or half dry—really a compromise between hay and silage. Sometimes salt is scattered over the layers while it is being stacked. It is more or less used in all countries where haymaking is difficult. While analyses show it to contain practically as much nutriment as hay or silage, cattle are not eager for it, and it can be considered only an emergency feed.

Unquestionably when large quantities of winter forage are needed for stock, silage must be depended upon, and undoubtedly, all things considered, it will be the most satisfactory feed. Practically the only Alaska forage plant thus far used as silage is beach rye, and the experiences with this plant of Prof. C. C. Georgeson, special agent in charge of the Alaska Agricultural Experiment Stations, and of others who have grown it, show it to be both palatable and nutritious. In all probability other Alaskan grasses, and perhaps other plants, will be found to be quite as satisfactory.

Where timber is available silos may be constructed of logs, like the one at the Sitka Experiment Station. This silo has the advantage of enabling a man to utilize his own labor. On the other hand, the material for stave silos can be secured at very reasonable prices, and this doubtless is the best silo to use in the timberless regions.

FOOD VALUE OF NATIVE ALASKAN GRASSES.

Chemical analyses have been made of the principal Alaskan grasses, and while these can be properly interpreted only in connection with

digestion experiments, their comparison with the analyses of standard grasses furnishes some measure of their value.

Analyses of Alaskan grasses (air-dried samples taken when in flower).

Species	Water.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Calamagrostis langsdorfii (Bluetop)	7.18	4.58	1.03	40.37	42.94	3.90
Carex cryptocarpa (Sedge)	5.85	10.32	2.12	45.34	25.72	10.65
Elymus mollis (Beach rye)	11.92	12.71	2.26	35.29	30.31	7.51
Phleum pratense (Timothy)	8.59	8.94	2.14	45.69	30.06	4.58
Poa pratensis (Bluegrass)	8.11	8.94	2.04	41.45	34.24	5.22
Deschampsia bottnica (Silver-top)	8.75	7.44	2.07	47.05	31.54	4.15
Calamagrostis aleutica	8.33	10.00	1.37	37.89	38.89	4.52

Analyses of standard grasses for comparison.

Species.	Water.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Poa pratensis (Bluegrass)	17.44	10.80	3.45	46.10	22.09	7.35
Agrostis alba (Redtop)	14.30	8.48	2.84	46.77	21.71	5.90
Phleum pratense (Timothy)	15.01	6.01	3.01	41.90	29.59	4.48
Dactylis glomerata (Orchard grass)	14.30	7.34	2.28	47.08	23.58	5.42
Deschampsia cæspitosa (Silver-top)	14.30	9.04	1.06	37.20	29.03	9.37
Calamagrostis canadensis (Bluejoint)	6.87	11.19	3.45	35.82	37.18	5.49

The analyses of the Alaskan grasses were all made by the Bureau of Chemistry of the Department of Argiculture, and with the exception of the first three, from material collected in 1904, were originally published in Bulletin No. 48, Office of Experiment Stations. The other analyses have been compiled from various authorities.

CULTIVABLE FORAGE CROPS.

The experiences of a number of individual investigators, as well as the tests made at the Sitka and Kenai experiment stations, throw a good deal of light on the possibility of growing fodder plants and forage crops on cultivated land. Much more testing is necessary, however, before some of the conclusions which at present seem probable can be considered demonstrated.

In the way of grasses the tests made at Sitka by Professor Georgeson on muck soils showed tall meadow oat-grass to be the most promising. Tall fescue, bluegrass, meadow foxtail, and redtop did fairly well, while orchard grass, timothy, and Italian rye-grass were not promising. From observations on a number of these and other grasses introduced by chance, some rather definite conclusions may be drawn. Timothy is more or less abundantly introduced at various places on the coast, but does not as a rule thrive very well, being often inferior in size to the native mountain timothy. It is altogether

probable, however, that a variety of timothy suited to the conditions might readily be secured by selection, as chance specimens of the plant seen were very fine. The success of such a selection, however, will largely depend on the possibility of growing seed in Alaska.

Among other useful grasses that have become accidentally introduced and show marked adaptability to the conditions are redtop, rough-stalk meadow grass, bluegrass, and fowl meadow grass.

White clover thrives everywhere along the coast and is an aggressive plant. Red clover and alsike are not promising and alfalfa does not thrive.

In the way of cereals, the earliest varieties of oats and barley will mature for two or possibly three out of five seasons. Of course, such a crop is not entirely lost if the grain fails to mature, as it can be utilized as hay or silage. On this account it will probably be wisest to grow the crop mixed with field peas, as such a mixture will make excellent silage, whereas oats alone could only be preserved as hay, a difficult thing to do so late in the season. It is to be clearly understood that under present conditions it is unnecessary to plant any cultivated ground in such crops as grass, or perhaps even legumes. The above facts are of value simply as indicating what well-known forage plants will thrive, thus to some extent showing the future agricultural possibilities of Alaska.

SILAGE ALONE AS A RATION FOR MILCH COWS.

The writer has been unable to find any published data on results obtained by feeding milch cows nothing but grass silage. Presumably the best of results would not thus be obtained.

In order to obtain some light on the subject, Dr. James Withycombe, director of the Oregon Experiment Station, was requested to conduct such a test. The results of his experiment are reported as follows:

The silage test was made on a nonbreeding Jersey cow which freshened in February, 1902. In January, 1904, this cow was fed largely on silage, with a moderate amount of mill feed and light ration of hay as a preliminary preparation. From February 1 to April 30 she was fed wholly on corn silage and a light ration of ground oats daily. She consumed during the ninety days' feeding 3,785 pounds of corn silage and 270 pounds of the oat chop. The following table shows variation in weight and her production:

Date.	Weight.	Milk.	Average test.	Fat.	Date.	Weight.	Milk.	Average test.	Fat.
	Lbs.	*Lbs.*	*P. ct.*	*Lbs.*		*Lbs.*	*Lbs.*	*P. ct.*	*Lbs.*
December 1	955	196	5.8	11.36	March 1	925	195	5.8	11.31
January 1	945	199	5.9	11.74	April 1	890	221	5.5	12.15
February 1	905	178	5.7	10.15	April 30	860			

The cow was in good condition at the close of the experiment, which indicates that silage may with safety constitute a large portion of the ration of a dairy cow.

This experiment was undertaken at the suggestion of the Government agrostologist to determine in a measure if it were practicable to winter cattle in Alaska on grass silage.

The 3 pounds of ground oats were fed daily for the purpose of bringing the corn silage up to a protein standard equaling that of mixed-grass silage.

Protein percentage of feed consumed.

Ground oats	11.56
Corn silage	1.58
Protein percentage of grass silage (approximately)	2.72

Average amount of total protein consumed daily in 42 pounds of corn silage and 3 pounds of ground oats, 1.01 pounds. Approximate amount of protein contained in 40 pounds of grass silage, 1.08 pounds.

It will thus be seen that this test indicates that cattle can be successfully wintered on grass silage and that dairy cows may be expected to yield a reasonable amount of milk when fed exclusively on this feed.

ALASKAN EXPERIENCE IN STOCK RAISING.

Hogs.—A few hogs were seen at various Alaska villages. They are fed refuse, and graze on various succulent plants when obtainable. They are very fond of wild rice, the bulb of a lilylike plant (*Fritillaria kamtschatica*), which, however, is not very abundant. Unfortunately these animals are prone to feed on fish offal and other sea refuse, and as a consequence their flesh has a disagreeable flavor. Unquestionably there is too little feed adapted to hogs to make their raising profitable in Alaska.

Goats.—Angora goats have been tested by the Alaska Commercial Company at Kadiak and by Rev. C. P. Coe at Wood Island. According to Mr. Washburn, formerly resident superintendent of the Alaska Commercial Company at Kadiak, the company had a few years ago about 50 head of these animals on Ukamak Island, near Kadiak, which were entirely self-sustaining, increasing about 60 per cent each year. The mohair is said to have been good, both in quantity and quality.

Rev. C. P. Coe, of Wood Island, has several head of Angora goats which have passed the last two winters with but little care. This year his herd has shown very satisfactory increase, and no difficulty is anticipated in wintering the kids. A large part of their feed is derived from willows and other browse, and where this is abundant the animals need but little feed in winter. Owing to their tractability and the ease with which they are kept, especially where browse is abundant, Angora goats should prove most useful animals both for the natives and for whites.

Sheep husbandry.—Two definite attempts have been made to establish sheep raising in south Alaska, though small numbers have been kept at various points for short periods. The first attempt was made by the Alaska Commercial Company, which in 1883 imported a band of about 300 sheep from California. Unfortunately no accurate record of this experiment is available, and the accounts of various persons differ considerably. Many of the sheep died the first winter, according to some reports from lack of shelter, according to others from scab. The remainder were kept on a small island near Kadiak, where the only shelter was a small grove of spruce, but in winter they were usually transferred to new grazing grounds where they could feed on the tall, dry grass. In very severe weather they were sometimes sheltered and fed hay. These sheep are said to have yielded about 5 pounds of excellent wool per head each year, and the annual increase is reported to have been about 60 per cent of the adult animals. No particular care was given them, and the last were slaughtered about six years ago. The venture, even excluding the loss of the first winter, seems not to have been profitable.

The only sheep now in Alaska are on the ranch of the Frye-Bruhn Company, near Kadiak, who have about 80 head. These sheep are the remnant of 9,000 which were shipped in from Oregon in 1902 and 1903, the remainder having perished. At first sight it would seem that this appalling loss of more than 98 per cent was conclusive evidence that sheep raising in Alaska is not likely to prove profitable. Inquiry into the causes of the mortality do not bear out this conclusion necessarily. About 500 of the sheep were drowned in March, 1903, by being caught at the head of a narrow cove by the incoming tide. One hundred and fifty head were lost by becoming frightened and jumping over cliffs. The rest of those that died succumbed to scab, which broke out in January, 1903. Owing to lack of shelter it was then impossible to treat them by dipping, as that would practically have been equivalent to killing them. The result was that all but 80 died of the disease. Thus all the mortality was due to causes entirely preventable. It was interesting to learn that several head of these sheep which ran wild survived the winter without care, and the writer was informed by trustworthy witnesses of other cases of this kind. In the light of present knowledge it is difficult to say whether sheep can be profitably raised in southwestern Alaska.

In regard to the two attempts which have been made, it is noteworthy that in both instances the animals were shipped from a comparatively warm and dry climate to one cool and notably wet; furthermore, that none of them perished from any cause directly connected with the Alaska conditions.

There are, however, some further difficulties in connection with

sheep raising in Alaska which need careful consideration. It is the general opinion in Kadiak that in an ordinary winter sheep can not safely be left without care after the beginning of January. Indeed, many would place the time a month or six weeks earlier. New grass never appears before May 15, and often not until June 1. Therefore, under the best of conditions, sheep will need four and a half months of feeding and shelter. The superintendent of the Frye-Bruhn ranch, after one winter's experience, thinks that feed and shelter should be given for a longer period than that mentioned.

Another serious difficulty lies in the lateness of the lambing season. It is generally agreed that lambing should not take place before June 1. The lambs will need shelter and feed by December 1 or earlier, unless one takes serious chances of losing many.

Whether sheep raising could be made profitable at present under such conditions remains to be demonstrated. The mere fact that sheep in small numbers have wintered without care is no proof that successful sheep husbandry can thus be carried on, nor even that one or two months' feeding will suffice. The risks involved in such a procedure are too great to warrant a careful stock raiser in taking any chances.

Destructive wild animals are no menace to sheep raising on the islands. Eagles may destroy a few lambs, but these birds are easily exterminated. Kadiak bears are too scarce and too easily destroyed to merit consideration. On the mainland, however, both wolves and brown bears may prove troublesome.

In the light of present knowledge one is safe in saying that sheep can be raised on the Alaska coast if adults are given five months' feed and shelter and the lambs a month more—this with the ordinary sheep of the western ranges. With more hardy breeds better adapted to the conditions the outlook for success would be better. It need hardly be said that extreme caution should be taken to import only perfectly healthy animals. The great mortality caused by scab and the great danger of such a disease as foot-rot in a damp climate demand that extreme care be taken not to introduce these diseases.

Cattle.—Cattle have been raised at nearly all the Alaskan coast settlements ever since the Russian occupation. Some of the original stock, according to local tradition, is still represented in the band of cattle at Nannilchuck. These are small animals, but said to be very hardy. Nearly all of the cattle kept near the villages are milch cows, mostly grades, but a number of Holsteins and Jerseys were seen. When owned by whites the animals are given shelter and feed for about five months. When they belong to the natives they are forced to exist through the winter with little or no care, eking out an existence by feeding on browse and seaweeds. No accurate data could be

gathered concerning the amount and character of the milk yield, but it was universally said that the milk is most excellent in summer, and good in winter when the animals are properly fed. It is unfortunate that no accurate records could be obtained as to the winter yield of cows fed only on native hay or silage.

Several herds of beef cattle have been successfully maintained in the neighborhood of Kadiak. The experience of the Alaska Commercial Company is thus summarized by Mr. Washburn, the former superintendent at Kadiak:

> We have bred stock on the islands of Kadiak, Ukamak, and on Long Island. On Long Island we have about 40 head of cattle. These cattle are fed from two to six weeks each winter. The remainder of the time they have been able to get their own subsistence. During occasional winters we have carried our stock through with no feeding. We have had very good increase from them, and should say that the percentage of calves raised from the breeding cows is about 75. The cattle on this island have not been housed except during the short period when we were obliged to feed them.
>
> On Ukamak Island we have a herd of about 20 head, which are entirely self-sustaining. We have not found it necessary either to feed or shelter these cattle during the winter season, and the increase has been fully as good as that of the herd on Long Island.
>
> On Kadiak Island we have not kept any stock cattle, but only a herd of dairy cows and some working horses. These we have, of course, fed regularly during the winter season for about five months. We are able to cure sufficient hay on a lot we have leveled, and we have used the only mowing machine in western Alaska. We have obtained very good results from feeding the Alaska hay to both cows and horses, and find that they require no more grain when fed this hay than when we feed hay imported from California.

The Frye-Bruhn Company, of Seattle, began operations near Kadiak in July, 1903, importing about 200 head of beef cattle, mostly Herefords. Owing to unpreparedness and inexperience, about 140 head of this number were lost during the first year. Most of these were killed by falling over cliffs. Owing to the fact that the earliest grass appears on the steep southerly slopes, the cattle crowded in such places; in some instances the sod, loosened by the frost, gave way and precipitated them over the cliffs. In other cases the cattle used their horns when crowded, the wounded ones losing their foothold in endeavoring to escape. As precautions, more care is taken in selecting the early feeding grounds and the cattle have been dehorned.

The common experience of cattle owners in Alaska has been that the animals fatten readily on the grass in the spring, and remain in good condition without care until late in the autumn. Some Herefords slaughtered at Kadiak in July furnished beef of remarkably fine quality.

From the experience had at the Kenai Experiment Station, oxen keep in good working condition all winter on no other feed than native grass hay and silage, and the limited experience of others

has given similar results. It is not probable, however, that animals will remain fat on such feeds alone.

Nothing has been done up to the present time in the way of introducing breeds that are likely to be especially adapted to the peculiar conditions. It is highly probable, as has been pointed out by Professor Georgeson, that long-haired hardy breeds like the Galloway or the West Highland cattle will prove much more successful than breeds adapted primarily to a drier and warmer climate.

POPULATION AND AVAILABLE MARKETS.

No very accurate data are available as to the present population of the Alaska coast towns and villages, which furnish the only markets close to the grass lands. The population of the principal towns along the coast is approximately as follows: Sitka, 1,500; Valdez, 1,000; Seward, 500; Kadiak, 50; Unalaska and Dutch Harbor, 600. The total population from Valdez to Unalaska, inclusive, is about 8,000, of whom less than one-half are whites. From Valdez to Sitka, excluding the former, the population is perhaps 4,000, about half of them white. Thus the coast of Alaska from Sitka to Unalaska provides a market population at present of not more than 6,000 people, as no market for meat or dairy products can be expected so far as the natives are concerned.

No account is here taken of the towns lying along the interior channels in southeastern Alaska, whose populations aggregate perhaps 8,000 whites, though a portion of this market could perhaps be reached.

Skagway and Valdez are the principal south Alaskan points which supply the interior, and consequently are of especial importance in considering markets.

A considerable market for beef and dairy products could perhaps be established by shipping from Unalaska to the population of the Nome district and the lower Yukon. Unalaska is on the line of transportation from Puget Sound to Nome and the Yukon River, though at present few of the vessels stop there.

Thus the present available markets in Alaska for live-stock products are very limited. The supply for these markets at the present time is shipped from Puget Sound.

It is evident, however, that it is possible to raise in Alaska far more produce of this kind than the local markets can consume. The only other markets that can possibly be reached are those furnished by the cities of British Columbia and of the State of Washington. Freight rates are at present, and perhaps will be for some time to come, such that dairy products and wool are the only articles that could profitably be shipped to such distant ports.

No predictions can here be ventured concerning the future development of south Alaska. The present resources are mainly furs, fisheries, and mines. The fur industry is becoming less and less important. The fisheries are already highly developed, but are capable of considerable increase. The mines undoubtedly will become more and more important. It is probable, too, that the extensive explorations now carried on in prospecting for oil will result in the development of another important industry.

FREIGHTS AND TRANSPORTATION.

At the present time both freight and passenger rates to and between Alaskan ports may be considered moderate. The great bulk of the freight traffic is northward, a condition that is not unlikely to continue. Any permanent increase in the traffic to and from Alaskan ports will naturally be accompanied by a corresponding lowering of rates. The transportation companies doing business in south Alaska seem to be quite as liberal as conditions will permit, and so far as expressed sentiment goes their general policy will be the wise one of encouraging as far as possible any industry that promises to add to the sum total of the traffic.

DESIRABILITY OF SOUTH ALASKA AS A HOME.

Climate.—The south Alaska coast lies in the same latitude as northern Labrador, the north of Scotland, and the south of Sweden, but none of these regions is very similar to it. In fact, south Alaska has several peculiarities which render close comparison with any other region difficult. In general, the climate is a moist one, accompanied by no great extremes in temperature. The thermometer very seldom reaches zero in winter, nor does it exceed 75° F. in summer.

The following tables give the more important meteorological data as compiled from various published reports, localities in Sweden, Canada, and the State of Washington being included for comparison:

Monthly and annual mean temperatures at points in Alaska and elsewhere.

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.
Sitka[a]	31.4	32.9	35.6	40.8	47.0	52.4	55.4	55.9	51.5	44.9	38.1	33.3	43.3
Sitka[b]	34.2	33.0	37.2	41.9	46.9	51.6	54.4	56.6	52.3	45.7	39.8	36.0	44.5
Kadiak	30.0	28.2	32.6	36.3	43.2	49.5	54.7	55.2	50.0	42.3	34.7	30.5	40.6
Unalaska[a]	30.0	31.9	30.4	35.6	40.9	46.3	50.6	51.9	45.5	37.6	33.6	30.1	38.7
Unalaska[b]	33.5	30.5	32.6	35.2	40.4	45.9	49.6	50.3	46.0	40.4	34.6	32.8	39.3
Port Angeles, Wash	34.7	36.7	41.7	45.6	50.6	54.0	56.6	56.8	52.7	47.7	42.4	38.2	46.1
Ottawa, Canada	11.9	12.2	17.6	41.5	63.6	66.9	70.4	68.7	57.7	43.1	34.5	17.8	42.1
Stockholm, Sweden	33.5	29.5	33.8	39.5	52.5	57.0	59.1	59.3	53.6	40.6	35.6	27.3	43.4

[a] From records kept by the Russian Government.
[b] From records of the United States Signal Service

Average precipitation at points in Alaska.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.	Total precipitation, May 1 to Sept. 30.
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Sitka	7.95	8.02	7.78	5.08	3.89	3.87	4.14	6.67	10.94	12.96	10.77	8.52	90.54	29.51
Kadiak	6.56	3.70	4.86	4.01	5.92	4.91	3.38	4.97	7.26	8.09	6.56	7.94	68.16	26.44
Unalaska	13.81	7.68	6.48	7.51	4.49	4.26	2.78	3.40	8.64	11.98	9.30	11.81	92.14	23.57

In comparing the data for Sitka, Kadiak, and Unalaska it will be noted that the average mean temperature of Sitka is a little higher than that of Kadiak, which in turn is higher than that of Unalaska. It will also be noted that Sitka and Unalaska have about the same rainfall—considerably greater than that of Kadiak.

A matter of more practical consequence than either the copious rainfall or the comparatively high mean temperature is the rather low total of effective temperatures during the months from May to September, inclusive. By effective temperature is meant that above 43° F., at which plant growth practically begins. These totals, as compiled by Evans,[a] are as follows:

Sitka	1,479.1
Kadiak	1,152.1
Unalaska	624.5
Port Angeles, Wash	1,671.0
Ottawa, Canada	5,424.7
Scotland	1,692.7
Stockholm, Sweden	2,704.9

The difference in totals between Sitka and Kadiak is very striking, but not so much as that between Kadiak and Unalaska. Undoubtedly this effective temperature factor is the principal cause of the sharp demarcation between the timbered and the timberless regions on the Alaska coast.

Garden products.—This same factor—the low total of effective temperatures—limits also the variety of garden products that can be grown, but along the whole coast a considerable variety of vegetables is successfully raised, such as potatoes, turnips, cabbage, cauliflower, Brussels sprouts, kale, lettuce, peas, radishes, and rhubarb. Red currants and red raspberries grow wild on Cook Inlet, and these hardy varieties will thrive at most places along the coast—at Sitka even the ordinary garden varieties ripening. In southeastern Alaska salmon berries, cranberries, and huckleberries grow wild in abundance.

[a] Bulletin No. 48, Office of Experiment Stations, U. S. Department of Agriculture.

Fuel.—In the timbered region a supply of fuel is easily obtainable, while in the timberless country a rather scant quantity is secured from scrubby willows and alders and from beach drift. Coal of an inferior quality, but still fairly satisfactory for domestic use, is abundant along Cook Inlet. At present none of this is mined, but considerable quantities are gathered from exposed ledges, or from drift on the beaches. Most of the coal used along the Alaska Peninsula, however, is at present shipped from Puget Sound. In some localities the paraffin residue from oil seepage is utilized as fuel.

CHOICE OF A LOCATION.

In general, Kadiak and the neighobring islands and the Cook Inlet country are the most favorable places for live-stock raising on account of a great luxuriance of grasses and contiguity to timber. The Cook Inlet region enjoys the reputation of being the garden spot of the Alaska coast, apparently producing finer vegetables than elsewhere, though lying farther north than the Alaska Peninsula and most of the territory described in these pages. The accessible grass lands here are, however, comparatively limited.

On the other hand, Unalaska and the neighboring islands, while possessing less abundant grass and perhaps a less favorable climate, can perhaps reach markets in the Nome region and on the lower Yukon. At Yakutat, while the grass is not overabundant, the location is more favorable for shipments southward.

The prime requisite of any Alaska location is a sufficiently large available supply of winter forage. Of summer range there is an abundance nearly everywhere, but the utilization of this is definitely limited by the number of cattle one can safely winter. The all-important point is therefore to have a sufficient acreage of land from which hay or silage can be secured. By selecting locations on the flat lands that so commonly occur at the heads of the narrow fiords one can easily control for all practical purposes great areas of grazing lands.

The writer can not refrain from quoting here the following opinion of a widely traveled man from California, who for three years has been engaged in placer mining on the beach on the west side of Kadiak Island and who is seriously considering taking up a homestead and bringing his family to Alaska:

In all my travels I have never found a place where one can live so well or so cheaply as I have done for the past three years. I can raise all sorts of hardy vegetables and berries, besides the wild ones, and have unlimited grass to keep cattle and sheep. Fish of the choicest sorts—salmon, halibut, cod, and many others—are very abundant, and the stream flowing by my cabin door swarms with trout. In the way of big game there are bears. Of small game

ducks and geese are plentiful in the spring and fall, and fresh gull eggs may be had for the gathering. To add to all this, if ready money is not available, I can always make good wages at least by washing out gold on the beach.

Surely there is here a combination of resources that makes failure well-nigh impossible.

LAND LAWS APPLYING TO ALASKA.

The following report regarding the methods by which title may be secured to agricultural lands in Alaska was prepared in the office of the Commissioner of the General Land Office, through the courtesy of the Secretary of the Interior. It refers solely to acquiring title to agricultural lands and not to the town-site or mineral laws, or to mission claims under section 27 of the act of June 6, 1900 (31 Stat. L., 330):

Section 1 of the act of Congress approved May 14, 1898 (30 Stat. L., 409), extending the homestead laws to Alaska, may be summarized as follows:

First. Extending the homestead laws and the rights incident thereto to the district of Alaska.

Second. Extending to such district the right to enter surveyed lands under provisions of law relating to the acquisition of title through soldiers' additional homestead rights.

Third. Granting the right to enter unsurveyed lands in said district under provisions of law relating to the acquisition of title through soldiers' additional homestead rights.

Fourth. Prohibiting the location in said district of any indemnity, deficiency, or lieu lands pertaining to any land grant whatsoever orginating outside of said district.

Fifth. Limiting each entry under this section to 80 rods along the shore of any navigable water, and reserving along such shore a space at least 80 rods between all such claims, and prohibiting the entry or disposal of the shore (meaning land lying between high and low water mark) of any navigable waters within said district.

Sixth. Limiting each homestead in said district, whether soldiers' additional or otherwise, to 80 acres in extent.

This section was amended by the act of March 3, 1903 (32 Stat. L., 1028), the provisions of which may be stated as follows:

The amendatory act does not specifically reenact that portion of the act of 1898 which granted the right to enter *unsurveyed* lands in the district of Alaska under the provisions of law relating to the acquisition of title through soldiers' additional rights, but it is provided thereby "that no more than one hundred and sixty acres shall be entered in any single body by such scrip, lieu selection, or soldiers' additional homestead right," which seems to negative any intention to modify or repeal the existing law with regard to the exercise of such rights in the district of Alaska further than to limit the amount which may be entered in a single body to 160 acres. Further, that portion of the amendatory act which provides that "no indemnity, deficiency, or lieu-land selections pertaining to any land grant outside of the district of Alaska shall be made, and no land scrip or land warrant of any kind whatsoever shall be located within or exercised upon any lands in said district, except as now provided by law," seems to

recognize that there are such outstanding rights; but, unless soldiers' additional homestead rights are thereby considered as scrip rights, this Department is not advised as to any other law permitting the exercise of any such rights in the district of Alaska. Soldiers' additional homestead applications, under sections 2306 and 2307, Revised Statutes, are received as heretofore, but not more than 160 acres can be taken in a single body.

The act of 1898 is amended so as to increase the amount of land which may be entered as a homestead in the district of Alaska to 320 acres, and in providing therefor grants such rights to "any person who is qualified under existing laws to make homestead entry of the public lands of the United States who has settled upon, or who shall hereafter settle upon, any of the public lands of the United States situated in the district of Alaska, whether surveyed or unsurveyed." If a person be qualified, therefore, to make homestead entry under existing laws, he may enter not to exceed 320 acres, upon which he may have settled, in the district of Alaska, and without regard to the amount he might be authorized to make homestead entry of elsewhere; but the right to locate a soldier's additional homestead right in the district of Alaska, without settlement, is not thereby changed. Only 160 acres or less may be commuted.

No entry of any kind in the district of Alaska can, however, be allowed for land extending more than 160 rods along the shore of any navigable water, which is twice the extent originally permitted by the act of 1898, and along such shore a space of at least 80 rods is reserved between all claims, being the same as originally provided in the act of 1898.

HOMESTEADS.

The homestead laws secure to qualified persons the right to settle upon, enter, and acquire title to not exceeding 320 acres of public land, by establishing and maintaining residence thereon and improving and cultivating the land for the continuous period of five years.

A homestead entryman must be the head of a family or a person who has arrived at the age of 21 years, and a citizen of the United States, or one who has filed his declaration of intention to become such, as required by the naturalization laws, to which section 5 of the act of March 3, 1891 (26 Stat. L., 1095), attaches the conditions that he must not be the proprietor of more than 160 acres of land in any State or Territory, and that since August 30, 1890, he has not acquired title to, nor is now claiming under any of the agricultural public-land laws, an amount of land which, together with the land now applied for, will exceed in the aggregate 320 acres.

Where a wife has been divorced from her husband or deserted, so that she is dependent upon her own resources for support, she can make homestead entry as the head of a family or as a femme sole.

Where an unmarried woman settles upon a tract of public land, improves the same, establishes and maintains a bona fide residence thereon with the intention of appropriating the same for a home under the homestead law, and thereafter marries before making entry of said land, or before making application to enter said land, she does not, on account of her marriage, forfeit her right to make entry and receive patent for the land: *Provided*, That she does not abandon her residence on said land and is otherwise qualified to make homestead entry: *And provided further*, That the man whom she marries is not, at the time of their marriage, claiming a separate tract of land under the homestead law. (Act June 6, 1900, 31 Stat. L., 683.)

APPLICATION FOR A HOMESTEAD FOR SURVEYED LAND.

To obtain a homestead the party should select and personally examine the land and be satisfied of its character and true description.

He must file an application, stating his true name, residence, and post-office address, and describing the land he desires to enter, and make affidavit that he is not the proprietor of more than 160 acres of land in any State or Territory; that he is a citizen of the United States, or that he has filed his declaration of intention to become such, and that he is the head of a family, or over 21 years of age, as the case may be; that his application is honestly and in good faith made for the purpose of actual settlement and cultivation, and not for the benefit of any other person, persons, or corporation, and that he will faithfully and honestly endeavor to comply with all the requirements of law as to settlement, residence, and cultivation necessary to acquire title to the land applied for; that he is not acting as agent of any person, corporation, or syndicate in making such entry, nor in collusion with any person, corporation, or syndicate to give them the benefit of the land entered, or any part thereof, or the timber thereon; that he does not apply to enter the same for the purpose of speculation, but in good faith to obtain a home for himself, and that he has not, directly or indirectly, made, and will not make, any agreement or contract in any manner with any person or persons, corporation, or syndicate whatsoever, by which the title which he might acquire from the Government of the United States should inure, in whole or in part, to the benefit of any person except himself; and, further, that since August 30, 1890, he has not acquired title to nor is he claiming under any of the agricultural public-land laws an amount of land which, together with the land he is seeking to enter, will exceed in the aggregate 320 acres, and that he has not theretofore had the benefit of the homestead laws, and must pay the legal fee and that part of the commissions which is payable when entry is made, and furnish the usual nonmineral affidavit.

On compliance by the party with the foregoing requirements the receiver will issue his receipt for the fee and that part of the commissions paid, a duplicate of which he will deliver to the party. The matter will then be entered in the records of the district office and reported to the General Land Office.

The applicant must in every case state in his application his place of actual residence and his post-office address, in order that notices of proceedings relative to his entry may be sent him. The register and receiver will note the post-office address on their tract books.

INCEPTIVE RIGHTS OF HOMESTEAD SETTLERS.

An inceptive right is vested in the settler by the proceedings hereinbefore described. He must, within six months after making his entry, establish his actual residence in a house upon the land, and must reside upon and cultivate the land continuously in accordance with law for the term of five years. Occasional visits to the land once in six months or oftener do not constitute residence. The homestead party must actually inhabit the land and make it the home of himself and family, as well as improve and cultivate it.

At the expiration of five years, or within two years thereafter, he may make proof of his compliance with law by residence, improvement, and cultivation for the full period required, and must show that the land has not been alienated except as provided in section 2288, Revised Statutes (sec. 2291, Rev. Stat.), as amended by section 3 of the act of March 3, 1891 (26 Stat. L., 1095).

The period of continuous residence and cultivation begins to run at the date of actual settlement in case the entry at the district land office is made within the prescribed period (three months) thereafter or before the intervention of a valid adverse claim. If the settlement is on unsurveyed land, the latter period runs from the filing of plat in the district land office. (Act May 14, 1880, 21 Stat. L., 140.)

HOMESTEAD SETTLERS ON UNSURVEYED LANDS.

A homestead settler on unsurveyed public land not yet open to entry must make entry within three months after the filing of the township plat of survey in the district land office. (Act May 14, 1880, 21 Stat. L., 140.)

CULTIVATION IN GRAZING DISTRICTS.

In grazing districts stock raising and dairy production are so nearly akin to agricultural pursuits as to justify the issue of patent upon proof of permanent settlement and the use of the land for such purposes.

Proofs can only be made by the homestead claimant in person, and can not be made by an agent, attorney, assignee, or other person, except that in case of the death of the entryman proof can be made by the statutory successor to the homestead right in the manner provided by law.

Sections 2291 and 2292, Revised Statutes, provide for obtaining title to lands entered by a homestead settler by his heirs. The act of June 8, 1880 (21 Stat. L., 166), provides for homestead claimants who become insane.

HOMESTEAD CLAIMS NOT LIABLE FOR DEBT AND NOT SALABLE.

No lands acquired under the provisions of the homestead laws are liable for the satisfaction of any debt contracted prior to the issue of the patent. (Sec. 2296, Rev. Stat.)

The sale of a homestead claim by the settler to another party before becoming entitled to a patent vests no title or equities in the purchaser as against the United States. In making final proof the settler is by law required to swear that no part of the land has been alienated except for church, cemetery, or school purposes or the right of way for railroads, canals, or ditches for irrigation or drainage across it. (Sec. 2288, Rev. Stat., as amended by sec. 3 of the act of March 3, 1891, 26 Stat. L., 1095.)

SOLDIERS AND SAILORS' HOMESTEAD RIGHTS.

Any officer, soldier, seaman, or marine who served for not less than ninety days in the Army or Navy of the United States during the rebellion, and who was honorably discharged and has remained loyal to the Government, and who makes a homestead entry of 320 acres or less on any land subject to such entry, is entitled under section 2305 of the Revised Statutes to have the term of his service in the Army or Navy, not exceeding four years, deducted from the period of five years' residence required under the homestead laws.

If the party was discharged from service on account of wounds or disabilities incurred in the line of duty the whole term of enlistment, not exceeding four years, is to be deducted from the homestead period of five years; but no patent can issue to any homestead settler who has not resided upon, improved, and cultivated his homestead for a period of at least one year after he commenced his improvements. (Sec. 2305, Rev. Stat.)

Similar provisions are made in the acts of June 16, 1898 (30 Stat. L., 473), and March 1, 1901 (31 Stat. L., 847), for the benefit of like persons who served in the late war with Spain or during the suppression of the insurrection in the Philippines.

A party applying to make entry under the provisions of section 2304 must file with the register and receiver a certified copy of his certificate of discharge, showing when he enlisted and when he was discharged; or the affidavit of two respectable, disinterested witnesses corroborative of the allegations contained in the prescribed affidavit (Form 4–065) on these points, or, if neither can be procured, his own affidavit to that effect.

The widow or, in case of her death or remarriage, the guardian of minor children may complete a filing made by the soldier or sailor as above, and patent will issue accordingly.

SOLDIERS' ADDITIONAL HOMESTEAD ENTRY.

Any officer, soldier, sailor, or marine who served for not less than ninety days in the Army or Navy of the United States during said wars, who had, prior to June 22, 1874, the date of the approval of the Revised Statutes, made a homestead entry of less than 160 acres, may enter an additional quantity of land, adjacent to his former entry or elsewhere, sufficient to make, with the previous entry, 160 acres. (Rev. Stat., 2306.) This right was extended by section 2307, Revised Statutes, to the widow, if unmarried; otherwise to the minor orphan children by proper guardian. If there be no widow, unmarried, and no minor orphan children, the right is held to be an asset of the soldier-entryman's estate, to be disposed of by his personal representative as other personal property. (29 L. D., 510 and 658.) An assignment by the heirs will be accepted if accompanied by a certificate of the proper court showing that no administration has ever been had on the soldier's estate and that they are all the heirs entitled to the right. The right was formerly regarded as a personal one and not transferable, but under authority of the decision of the Supreme Court of the United States in the case of Webster *v.* Luther (163 U. S., 331), it is now held to be assignable without restriction, and residence and cultivation are not required in its exercise, either by the original beneficiary or by his assignee, whether the original entry was perfected or abandoned (24 L. D., 502).

It was formerly the practice, on proof of military service and original entry, under section 2306, Revised Statutes, to issue a certificate in the name of the soldier-entryman, showing his additional right and its area, but the practice was discontinued by circular of February 13, 1883 (1 L. D., 654), and it is held that there is no statutory authority for the same and that the soldier can obtain the right for himself and sell it to another without certification (23 L. D., 152).

By the act of March 3, 1893 (27 Stat. L., 593), provision is made that where soldiers' additional homestead entries have been made or initiated upon a certificate of the Commissioner of the General Land Office of the right to make such entry, and the certificate of right is found to be erroneous or invalid for any cause, the party in interest thereunder on making proof of his purchase may, if there is no adverse claimant, perfect his title by payment of the Government price for the land, but no person may acquire more than 160 acres through the location of any such certificate.

By the act of August 18, 1894 (28 Stat. L., 397), all certificates regularly issued are declared to be valid, notwithstanding any attempted sale or transfer, and holders thereof desiring to exercise their right of entry in their own names

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must file such certificates in the General Land Office, together with satisfactory proof of ownership and of bona fide purchase for value. If, upon examination, the proof so filed is satisfactory, an additional certificate will be attached to the original authorizing the location thereof, or entry of land therewith, in the name of the assignee or his assigns. (Circular of October 16, 1894; 19 L. D., 302.)

Existing homestead laws, while recognizing settlement upon unsurveyed public lands, do not authorize the entry or the patenting thereof until the public surveys have been regularly extended over them. This section as amended, however, in terms authorizes the entry of unsurveyed lands in Alaska, and makes provision for a private survey for the purpose of patenting the claim, if the public surveys have not been extended thereto at the time it is desired to submit proof, as is hereinafter referred to.

In executing surveys for homestead applications the instructions now prevailing will be followed, and the limit of 160 rods as to frontage will be measured along the meandered line of said frontage.

The form of the tract sought to be entered, if upon unsurveyed land, is prescribed in the act as follows:

> If any of the land * * * is unsurveyed, then the land * * * must be in rectangular form, not more than a mile in length, and located upon the north and south lines run according to the true meridian.

That is, the boundary lines of each entry must be run in cardinal directions, true north-and-south and east-and-west lines by reference to a true meridian (not magnetic), with the exception of the meander lines on meanderable streams and navigable waters forming a part of the boundary lines of the entry. Thus a frontage meander line, and other meander lines which form part of the boundary of a claim, will be run according to the directions in the Manual of Surveying Instructions issued by this Office, but other boundary lines will be run in true east-and-west and north-and-south directions, thus forming rectangles, except at intersections with meander lines.

In other respects the rules previously adopted to govern surveys of claims under the act of May 14, 1898, will continue to be followed, of course taking into consideration the limitations as to area of claims.

Every person who is qualified under existing laws to make a homestead entry of the public lands of the United States who settles or has settled upon any of the unsurveyed public lands of the United States in the district of Alaska with the intention of taking the same under the homestead law shall, within ninety days from date of settlement or prior to the intervention of an adverse claim, file the record of his location for record in the recording district in which the land is situated, as provided by sections 13 to 16 of the act of June 6, 1900 (31 Stat. L., 326 to 328).

Said record shall contain the name of the settler, the date of settlement, and such description of the land settled on, by reference to some natural object or permanent monument as will identify the same.

If at the expiration of the time required under sections 2291 and 2292, Revised Statutes, and as modified by section 2305, Revised Statutes, or at such date as the settler desires to commute under section 2301, Revised Statutes, the public surveys have not been extended over the land located, the locator may secure a patent for the land located by procuring, at his own expense, a survey of the land, which must be made by a deputy surveyor who has been duly appointed by the surveyor-general, in accordance with section 10 of the act of May 14, 1898 (30 Stat L., 409), and the provisions of the act of March 3, 1903, as herein set forth.

When the survey, either public or private, as herein provided for is approved by the surveyor-general under authority of this Office, the same rules should be followed as heretofore established governing the location of soldiers' additional homestead rights, in addition to which the settler must furnish the required proof of residence and cultivation.

The office of the surveyor-general of Alaska is located at Sitka.

Section 10 of said act of May 14, 1898, also provides that all affidavits, testimony, proofs, and other papers provided for by this act and by said act of March 3, 1891, or by any departmental or Executive regulation thereunder, by depositions or otherwise, under commission from the register and receiver of the land office, which may have been or may hereafter be taken and sworn to anywhere in the United States, before any court, judge, or other officer authorized by law to administer an oath, shall be admitted in evidence as if taken before the register and receiver of the proper local land office. And thereafter such proof, together with a certified copy of the field notes and plat of the survey of the claim, shall be filed in the office of the surveyor-general of the district of Alaska, and if such survey and plat shall be approved by him, certified copies thereof, together with the claimant's application, shall be filed in the United States land office in the land district in which the claim is situated, whereupon, at the expense of claimant, the register of such land office shall cause notice of such application to be published for at least sixty days in a newspaper of general circulation published nearest the claim within the district of Alaska, and the applicant shall at the time of filing such field notes, plat, and application to purchase in the land office aforesaid, cause a copy of such plat, together with the application to purchase, to be posted upon the claim, and such plat and application shall be kept posted in a conspicuous place on such claim continuously for at least sixty days, and during such period of posting and publication, or within thirty days thereafter, any person, corporation, or association having or asserting any adverse interest in, or claim to, the tract of land or any part thereof sought to be purchased, may file in the land office where such application is pending, under oath, an adverse claim setting forth the nature and extent thereof, and such adverse claimant shall, within sixty days after the filing of such adverse claim, begin action to quiet title in a court of competent jurisdiction within the district of Alaska, and thereafter no patent shall issue for such claim until the final adjudication of the rights of the parties, and such patent shall then be issued in conformity with the final decree of the court.

When a settler desires to commute, the survey and homestead application must cover his entire claim, but only 160 acres, or less, thereof may be commuted, in which event the entry will stand intact as to the portion not commuted, subject to future compliance with the requirements of law within the statutory period of seven years.

Entrymen who commute will be required to pay, in addition to the price of $1.25 per acre, the same fees and commissions as in final homesteads.

Whenever a settler or other claimant desires to make entry or submit final proof, he should address the register and receiver of the United States land office at Juneau, Alaska.

PLATES.

DESCRIPTION OF PLATES.

PLATE I. Map of Alaska, showing the approximate location of the grass-land areas in black.

PLATE II. Fig. 1.—View of the level lands at the head of Womans Bay, Kadiak Island. Similar areas occur at the heads of most of the inlets. Fig. 2.—Mowing beach rye on the Frye-Bruhn ranch.

PLATE III. Bluetop (*Calamagrostis langsdorfii*) on Kadiak Island, 6 feet high, July, 1904. The hillsides in the background were burned over during the preceding spring, and are covered with an equally luxuriant stand of the same grass.

PLATE IV. Fig. 1.—A view of Kadiak, November 7, 1903. A light fall of new snow covers the low mountains in the background. Fig. 2.—Another view of Kadiak, March 26, 1904. The small snowfall of this region is made very clear by these two pictures.

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FIG. 1.—A VIEW OF THE FLAT LANDS LYING AT THE HEAD OF WOMAN'S BAY, KADIAK ISLAND, ALASKA.

FIG. 2.—MOWING BEACH RYE ON KADIAK ISLAND, ALASKA.

BLUETOP (CALAMAGROSTIS LANGSDORFII) SIX FEET HIGH, ON KADIAK ISLAND, ALASKA, JULY, 1904.

The grass on the hillside in the background was just as luxuriant.

FIG. 1.—A VIEW OF KADIAK, ALASKA, NOVEMBER 7, 1903.

FIG. 2.—A DIFFERENT VIEW OF KADIAK, MARCH 26, 1904.

The small snowfall of this region is made very clear by these two pictures.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 83.

B. T. GALLOWAY, *Chief of Bureau.*

THE VITALITY OF BURIED SEEDS.

BY

J. W. T. DUVEL,

ASSISTANT IN THE SEED LABORATORY.

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F. H. HILLMAN, *Assistant Botanist.* J. W. T. DUVEL, *Assistant.*

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., May 29, 1905.

SIR: I have the honor to transmit herewith, and to recommend for publication as Bulletin No. 83 of the series of this Bureau, the accompanying technical paper entitled "The Vitality of Buried Seeds."

The experiments discussed were undertaken in order to determine the length of time that seeds of different species of plants will retain their vitality when buried at various depths. Seeds of both cultivated and wild plants were used, but special attention was given to weed seeds in order to ascertain what weeds can be eradicated by deep plowing and how long the soil must remain undisturbed before the vitality of the seeds will be entirely destroyed. The results of the first year's experiments show that the noxious character of weeds is closely associated with the length of time the seeds will remain viable in the soil, and that many weeds can be eradicated by plowing. Much additional information is given, showing the relative resistance of the seeds of cultivated plants and of those commonly designated as weeds, and the influence upon the preservation of vitality of the depth of burial, of hard seed coats, and of hulled as compared with unhulled seed.

This paper was prepared by J. W. T. Duvel, Assistant in the Seed Laboratory, and has been submitted with a view to publication.

The accompanying illustrations are necessary for a complete understanding of the paper.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE VITALITY OF BURIED SEEDS.

INTRODUCTION.

The preservation of the vitality of seeds when buried in the soil and the awakening of metabolic activity in such seeds on being exposed to conditions favorable to their germination are equally as important to the practical farmer as to the scientist. The intelligent farmer in order to combat noxious plants successfully should know how much time must elapse after heavy crops of weeds of various sorts are turned under before the ground can be plowed again with safety. He should also know what plants he can hope to eradicate in this way, for with many of our worst weeds this method would result only in failure. In fact, the reason why the majority of our most persistent weeds are so difficult to eradicate is because their seeds are capable of retaining their vitality for a number of years when buried in the soil. It thus becomes important to know how different species of seeds behave when buried under similar conditions, and how seeds of the same species behave when buried under different conditions.

KINDS OF SEEDS BURIED.

So much has already been written on the germination of seeds that have remained dormant in the soil for a number of years, in some cases even for centuries, that it seemed desirable to determine with some degree of accuracy the length of time that certain seeds will retain their vitality when buried in the soil under known conditions. Accordingly, in the autumn of 1902, 112 different samples of seeds were selected for these experiments, as follows:

TABLE I.—*List of seeds selected for the experiments.*

Laboratory test number.	Kind of seed.	Sample number.	Burial number as given on diagram.
	Poaceæ (grass family):		
16173	*Agropyron repens* (L.) Beauv. (couch grass)	100	31
16174	*Avena fatua* L. (wild oat)	71	9
16175	*Avena sativa* L. (oats)	24	8
16176	*Bromus secalinus* L. (cheat, chess)	34	36
16177	*Bromus racemosus* L. (upright chess, smooth brome-grass)	33	37
16178	*Chaetochloa verticillata* (L.) Scribn. (foxtail)	108	66
16179	*Chaetochloa glauca* (L.) Scribn. (yellow foxtail)	46	33
16180	*Chaetochloa viridis* (L.) Scribn. (green foxtail)	5	67
16181	*Eleusine indica* (L.) Gaertn. (wire-grass, crab-grass)	36	72
16182	*Elymus virginicus* L. (Virginia wild rye)	77	15
16183	*Elymus canadensis* L. (nodding wild rye)	74	13
16184	*Elymus triticoides* Buckl. (wild wheat)	69	14

TABLE I.—*List of seeds selected for the experiments*—Continued.

Laboratory test number.	Kind of seed.	Sample number.	Burial number as given on diagram.
	Poaceæ (grass family)—Continued.		
16185	*Festuca elatior* L. (meadow fescue)	38	35
16186	*Hordeum sativum* Jessen. (barley)	23	12
16187	*Panicum virgatum* L. (tall, smooth panicum)	70	32
16188	*Phalaris arundinacea* L. (reed canary grass)	93	34
16189	*Phleum pratense* L. (timothy)	112	68
16190	*Poa pratensis* L. (Kentucky bluegrass)	75	73
16191	*Secale cereale* L. (rye)	25	11
16192	*Sporobolus airoides* Torr. (hair-grass drop-seed)	12	69
16193	*Sporobolus cryptandrus* (Torr.) A. Gray (sand drop-seed)	63	71
16194	*Sporobolus cryptandrus* (Torr.) A. Gray (sand drop-seed—hulled seed)	13	70
16195	*Triticum aestivum* L. (wheat)	22	10
16196	*Zea mays* L. (corn—Boone County white)	14	1
16197	*Zea mays* L. (sweet corn—early Concord)	15	2
	Cyperaceæ (sedge family):		
16198	*Cyperus esculentus* L. (yellow nut-grass)	7	74
	Liliaceæ (lily family):		
16199	*Allium cepa* L. (onion)	27	39
	Convallariaceæ (lily-of-the-valley family):		
16200	*Asparagus officinalis* L. (asparagus)	32	16
	Moraceæ (mulberry family):		
16201	*Cannabis sativa* L. (hemp)	4	17
	Urticaceæ (nettle family):		
16202	*Boehmeria nivea* Gaud. (ramie)	2	75
	Polygonaceæ (buckwheat family):		
16203	*Fagopyrum fagopyrum* (L.) Karst. (buckwheat)	21	18
16204	*Polygonum pennsylvanicum* L. (Pennsylvania persicaria, smartweed)	9	40
16205	*Polygonum persicaria* L. (lady's-thumb, smartweed)	10	78
16206	*Polygonum scandens* L. (climbing false buckwheat)	11	41
16207	*Rumex salicifolius* Weinm. (willow-leaved dock)	107	76
16208	*Rumex crispus* L. (curled dock), not cleaned	103	39
16209	*Rumex obtusifolius* L. (broad-leaved dock, bitter dock)	102	77
	Chenopodiaceæ (goosefoot family):		
16210	*Axyris amaranthoides* L. (Russian pigweed)	1	81
16211	*Beta vulgaris* L. (sugar beet)	72	19
16212	*Chenopodium album* L. (lamb's quarters, white goosefoot)	96	79
16213	*Chenopodium hybridum* L. (maple-leaved goosefoot)	62	80
	Amaranthaceæ (amaranth family):		
16214	*Amaranthus retroflexus* (rough pigweed)	83	82
	Phytolaccaceæ (pokeweed family):		
16215	*Phytolacca americana* L. (poke, pigeon berry)	104	42
	Portulacaceæ (purslane family):		
16216	*Portulaca oleracea* L. (purslane, pussley)	86	83
	Sileuaceæ (pink family):		
16217	*Agrostemma githago* L. (corn cockle)	16	43
16218	*Alsine media* L. (common chickweed)	110	84
16219	*Vaccaria vaccaria* (L.) Britton (cowherb)	55	44
	Brassicaceæ (mustard family):		
16220	*Brassica nigra* (L.) Koch (black mustard)	67	87
16221	*Brassica oleracea* L. (cabbage)	17	45
16222	*Brassica campestris* L. (turnip)	40	88
16223	*Bursa bursa-pastoris* (L.) Britton (shepherd's purse)	3	89
16224	*Erysimum cheiranthoides* L. (wormseed, treacle mustard)	58	47
16225	*Neslia paniculata* (L.) Desv. (ball mustard)	85	46
16226	*Sisymbrium altissimum* L. (tall sisymbrium)	78	86
16227	*Thlaspi arvense* L. (field penny cress)	60	85
	Rosaceæ (rose family):		
16228	*Potentilla monspeliensis* L. (rough cinquefoil)	73	90
	Caesalpiniaceæ (senna family):		
16229	*Cassia marylandica* L. (wild senna, American senna)	52	48
	Fabaceæ (pea family):		
16230	*Lespedeza frutescens* (L.) Britton (wand-like bush clover)	43	52
16231	*Medicago sativa* L. (alfalfa, lucern)	59	49
16232	*Phaseolus vulgaris* L. (bean)	20	4
16233	*Pisum sativum* L. (pea)	19	5
16234	*Robinia pseudacacia* L. (locust tree, false acacia)	37	51
16235	*Trifolium hybridum* L. (alsike clover)	50	93
16236	*Trifolium pratense* L. (red clover)	49	50
16237	*Trifolium pratense* L. (red clover) harvest of 1900	54	91
16238	*Trifolium pratense* L. (red clover) hard seed from No. 16237	68	92
16239	*Trifolium repens* L. (white clover)	41	94
16240	*Vigna catjang* Walp. (Iron cowpea)	42	3
	Linaceæ (flax family):		
16241	*Linum usitatissimum* L. (flax, linseed)	30	53
	Anacardiaceæ (sumac family):		
16242	*Rhus glabra* L. (scarlet sumac)	47	20
	Malvaceæ (mallow family):		
16243	*Abutilon abutilon* (L.) Rusby. (velvet leaf)	111	54
16244	*Gossypium hirsutum* L. (cotton)	18	6
16245	*Hibiscus militaris* Cav. (halberd-leaved rose mallow)	31	55

TABLE I.—*List of seeds selected for the experiments*—Continued.

Laboratory test number.	Kind of seed.	Sample number.	Burial number as given on diagram.
	Hypericaceæ (St. John's wort family):		
16246	*Ascyrum hypericoides* L. (St. Andrew's cross)	44	95
	Onagraceæ (evening primrose family):		
16247	*Onagra biennis* (L.) Scop. (common evening primrose)	8	96
	Apiaceæ (carrot family):		
16248	*Apium graveolens* L. (celery)	94	57
16249	*Pastinaca sativa* L. (parsnip, wild)	95	56
	Oleaceæ (olive family):		
16250	*Fraxinus americana* L. (white ash)	105	21
	Convolvulaceæ (morning-glory family):		
16251	*Convolvulus sepium* L. (hedge bindweed, great bindweed)	56	23
16252	*Ipomœa lacunosa* L. (small-flowered white morning-glory)	81	22
	Cuscutaceæ (dodder family):		
16253	*Cuscuta polygonorum* Engelm. (smartweed dodder)	63	98
16254	*Cuscuta epilinum* Weihe. (flax dodder)	82	97
	Verbenaceæ (vervain family):		
16255	*Verbena hastata* L. (blue vervain)	66	100
16256	*Verbena urticifolia* L. (white vervain, nettle-leaved vervain)	79	99
	Solanaceæ (potato family):		
16257	*Capsicum annuum* L. (red pepper)	39	59
16258	*Datura tatula* L. (purple stramonium, jimson weed)	106	61
16259	*Lycopersicon lycopersicon* (L.) Karst. (tomato)	45	60
16260	*Nicotiana tabacum* L. (tobacco)	99	101
16261	*Solanum nigrum* L. (black nightshade, garden nightshade)	61	58
	Scrophulariaceæ (figwort family):		
16262	*Verbascum thapsus* L. (great mullen)	76	102
	Plantaginaceæ (plantain family):		
16263	*Plantago lanceolata* L. (ribwort, ribgrass, buckhorn)	88	105
16264	*Plantago major* L. (common plantain)	91	103
16265	*Plantago rugelii* Dec. (Rugel's plantain, broad plantain)	65	104
	Cucurbitaceæ (gourd family):		
16266	*Citrullus citrullus* (L.) Karst. (watermelon)	6	26
16267	*Cucumis melo* L. (muskmelon)	26	25
16268	*Cucumis sativus* L. (cucumber)	48	24
	Cichoriaceæ (chicory family):		
16269	*Lactuca scariola* L. (prickly lettuce)	98	107
16270	*Lactuca sativa* L. (lettuce)	28	62
16271	*Taraxacum erythrospermum* Andrz. (red-seeded dandelion)	90	106
	Ambrosiaceæ (ragweed family):		
16272	*Ambrosia artemisiaefolia* L. (ragweed)	87	63
16273	*Ambrosia trifida* L. (great ragweed)	53	28
16274	*Xanthium pennsylvanicum* Wallr. (Pennsylvania clotbur, cocklebur)	51	27
	Asteraceæ (aster family):		
16275	*Arctium lappa* L. (burdock, clotbur)	101	112
16276	*Bidens frondosa* L. (black beggar ticks)	84	64
16277	*Carduus arvensis* (L.) Robs. (Canada thistle)	80	111
16278	*Chrysanthemum leucanthemum* L. (whiteweed, oxeye daisy)	92	110
16279	*Grindelia squarrosa* (Pursh.) Dunal. (broad-leaved gum plant)	89	108
16280	*Helianthus annuus* L. (common sunflower, wild)	97	29
16281	*Helianthus annuus* L. (common sunflower, cultivated)	29	7
16282	*Onopordon acanthium* L. (cotton thistle, scotch thistle)	109	65
16283	*Rudbeckia hirta* L. (black-eyed Susan)	57	109
	Pinaceæ (pine family):		
16284	*Pinus virginiana* Mill. (scrub pine, Jersey pine)	36	30

HOW THE SEEDS WERE BURIED.

The foregoing list represents 109 species, 84 genera, and 34 families of plants. Carefully counted seeds of these samples were mixed with dry clay soil and packed in well-baked earthen pots (the common flowerpot used in greenhouses). The filled pots were covered with inverted clay saucers in order to prevent the seeds from being destroyed or becoming mixed with other seeds which might have been in the soil with which the pots were covered. By burying the seeds mixed with earth in porous clay pots of this character they were subjected to conditions almost identical with those which would exist if the seeds were buried either accidentally or by natural causes. The porous clay pots admitted of the free circulation of air and water.

The pots containing these seeds were buried at three different depths. Eight complete sets were buried from 6 to 8 inches below the surface, being covered approximately the same as would result from deep plowing. Twelve complete sets were covered to a depth varying from 18 to 22 inches, sufficiently deep in this latitude to be reasonably secure from the action of frost. Twelve more complete sets were buried at a depth varying from 36 to 42 inches where the conditions were nearly uniform, so far as the three factors which regulate the germination of seeds are concerned, namely, heat, moisture, and air (oxygen). Figure 1 shows the arrangement of the pots, which were of 6-inch, 4-inch, and 2-inch sizes, to accommodate the different kinds of seed.

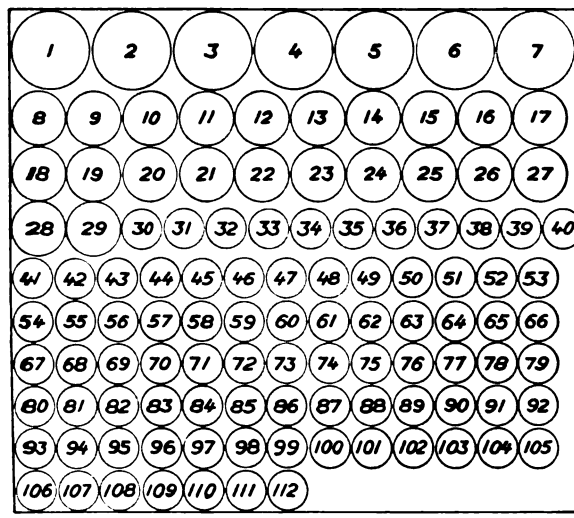


FIG. 1.—Diagram showing order in which seeds were buried.

These seeds were buried December 19 to 23, 1902, in a heavy clay soil on the Arlington Experimental Farm of the United States Department of Agriculture. With the exception of two of the duplicate samples of red clover, the seeds were of the harvest of 1902.

In each case a definite number of seeds was taken. Of the larger kinds, such as beans, peas, corn, etc., 100 seeds were used, but for the majority of the samples 200 seeds were taken. The seeds selected were for the most part of plants with which the greater number of the farmers throughout the United States are more or less familiar, either as plants of economic importance or as weeds.

In all 32 complete sets, representing 3,584 pots, were buried. One set from each of the three different depths is to be taken up as the conditions warrant and will be tested for vitality. The results of these tests are to be compared with the germination of seeds from the original bulk samples designated throughout this report as "controls."

The control samples are being stored in cloth bags in a dry room on the second floor of the Seed Laboratory. The first complete series of three sets was taken up in November, 1903, eleven months after they had been buried. The results of the first year's experiment are given in the following pages.

GERMINATION TESTS.

In making the germination tests of the buried seeds the contents of the pots, the mixture of seed and soil, were spread on sand in ordinary greenhouse flats. Along with these, in the same flats, were control samples taken from the original bulk lot of seeds, as previously mentioned. In addition, another complete set of control samples was tested in the germinating chambers of the Seed Laboratory. The temperatures given in the tables are those best suited for the germination of the different seeds.

For convenience the results of the germination tests have been divided into three groups, as follows:

A. Seeds in which the control samples, as well as those that were buried, gave only negative results when tested in the greenhouse.

B. Seeds which had either decayed or germinated and afterwards decayed while they were buried.

C. Seeds which had not completely lost their vitality while buried.

The first group, i. e., those in which both the control samples and those which had been buried failed to germinate when planted in flats in the greenhouse, consists of the following species:

1. *Axyris amaranthoides* L. (Russian pigweed).
2. *Boehmeria nivea* Guad. (ramie).
3. *Bursa bursa-pastoris* (L.) Britton (shepherd's purse).
4. *Cannabis sativa* L. (hemp).
5. *Chaetochloa viridis* (L.) Scribn. (green foxtail).
6. *Citrullus citrullus* (L.) Karst. (watermelon).
7. *Cyperus esculentus* L. (yellow nut-grass).
8. *Onagra biennis* (L.) Scop. (evening primrose).
9. *Polygonum pennsylvanicum* L. (Pennsylvania smartweed, persicaria).
10. *Polygonum persicaria* L. (lady's-thumb, smartweed).
11. *Polygonum scandens* L. (climbing false buckwheat).
12. *Sporobolus airoides* Torr. (hair-grass drop-seed).
13. *Sporobolus cryptandrus* (Torr.) A. Gray (sand drop-seed—hulled seed).

In this series the hemp should be discarded, as repeated tests failed to show any seeds from the bulk samples capable of germination. The control samples of the other seeds when tested in the germinating chambers germinated nearly as well and in some cases even better than the chamber tests which were made at the time the seeds were buried. Undoubtedly some of these seeds had decayed while buried in the soil; in fact, the watermelon seeds, *Axyris amaranthoides*, and *Sporobolus airoides* were marked "mostly decayed" when taken up. Generally speaking, the results show that the failure to germinate was not in the

seeds, but that the conditions in the greenhouse were at fault, and until other tests are made these results can not be discussed with any degree of satisfaction. On the other hand, it is certain that some of the smaller seeds failed to germinate because they were covered too deeply when sown in the flats in the greenhouse.

Polygonum scandens possibly should be classified in Table III, inasmuch as some of the seeds which were buried at depths of from 18 to 22 inches and from 36 to 42 inches showed a few sprouts at the time the seeds were taken up, but after being transferred to the greenhouse no seedlings were developed. However, the failure in the germination of the control sample of *Polygonum scandens* throws it into the first group (A) with the other two species of the same genus, i. e., *Polygonum pennsylvanicum* and *P. persicaria*.

The result of the tests of the buried seed of *Sporobolus cryptandrus*, as given in this group, should be compared with the germination of the unhulled seed as given in Table III, No. 64. The control samples of both the hulled and the unhulled seed which were sown in the greenhouse failed to germinate, but all three samples of the unhulled seed that had been buried gave some germination when tested in the greenhouse.

TABLE II.—*Results of tests of seeds which had either decayed or germinated and afterwards decayed while buried.*

Sample number.	Laboratory test number.	Kind of seed.	Chamber tests.			Greenhouse tests in sand.			
							Depth of burial.		
			Temperature.	Original sample.	Control.	Control.	6–8 inches.	18–22 inches.	36–42 inches.
			° C.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
14	16196	Zea mays (Boone County white corn)	20–30	99.5	99	.....	.....	.....	.....
15	16197	Zea mays (sweet corn)	20–30	98.5	98.5	.....	.....	.....	.....
16	16217	Agrostemma githago	20–30	99	98.5	.....	.....	.....	.....
17	16221	Brassica oleracea	20	85.5	82	.....	.....	.....	.....
18	16244	Gossypium hirsutum	20–30	77.5	72	.....	.....	.....	.....
19	16233	Pisum sativum	20–30	99	98	.....	.....	.....	.....
20	16232	Phaseolus vulgaris	20–30	97.5	98.5	.....	.....	.....	(a)
21	16203	Fagopyrum fagopyrum	20–30	100	98.5	.....	(b)	(c)	.....
22	16195	Triticum aestivum	20	99	96.5	.....	(d)	.....	(a)
23	16186	Hordeum sativum	20	100	98	.....	(d)	(d)	(d)
24	16175	Avena sativa	20–30	70.5	91.5	95.5	0	0	0
25	16191	Secale cereale	20	100	98.5	88	0	0	0
26	16267	Cucumis melo	20–30	96.5	97	88	0	0	0
27	16199	Allium cepa	20–30	94.25	88	70.5	0	0	0
28	16270	Lactuca sativa	20–30	100	98.5	91	0	0	0
29	16281	Helianthus annuus (cult.)	20–30	97	96.5	43	0	0	0
30	16241	Linum usitatissimum	20–30	93.5	95	83.5	0	0	0
31	16245	Hibiscus militaris	20–30	98.25	92	94	0	0	0
32	16200	Asparagus officinalis	20–30	80	e69	74	f0	f0	f0
33	16177	Bromus racemosus	20–30	100	98.5	92.5	a0	0	a0
34	16176	Bromus secalinus	20–30	88.5	77	95.5	0	0	0
35	16181	Eleusine indica	35	78.25	91.5	75	0	0	0
36	16284	Pinus virginiana	20–30	18	6.5	43.5	0	0	0
37	16234	Robinia pseudacacia	20–30	14	g11.5	3.5	0	0	0

a Many had germinated and afterwards decayed.
b Approximately 10 per cent had germinated; the remainder had decayed.
c An occasional old sprout was found.
d Approximately all had germinated and afterwards decayed.
e Clipped, 87 per cent; not clipped, 51 per cent.
f Practically all had sprouted; the sprouts from seeds buried at the 36–42-inch depth were found matted in the bottom of the pot.
g Clipped.

The corn, sweet corn, corn cockle, cabbage, cotton, peas, beans, buckwheat, wheat, and barley—the first ten samples given in the foregoing table—were all so unmistakably decayed when the seeds were taken up that the contents of the pots were thrown away, no greenhouse tests being made. The first six of these samples showed no trace of any remains of old sprouts; apparently all of the seeds had decayed before germination had taken place. If germination took place it must have been comparatively soon after burial, thus giving ample time for all of the old sprouts to decay beyond identification. This, however, seems hardly probable, considering that the seeds were buried during the latter part of December, 1902; moreover, the beans, buckwheat, and barley from some or all of the different depths showed clearly the remains of well-developed radicles.

The beans which were buried at depths of from 6 to 8 and from 18 to 22 inches had decayed, while many of those buried at a depth of from 36 to 42 inches had germinated and afterwards decayed. The buckwheat from the 6 to 8 inch depth showed that approximately 10 per cent had germinated, while at 18 to 22 inches there were only the remains of an occasional old sprout, and at 36 to 42 inches all of the seed had decayed. In the wheat the greater number of the grains that were buried from 6 to 8 and from 36 to 42 inches had germinated and then decayed, while those which were buried at a depth of from 18 to 22 inches showed only decayed seed. Approximately all of the barley at the three different depths had germinated and afterwards decayed.

The last fourteen species given in this table were marked "decayed" when the seeds were taken up, but as the conditions were not so clearly indicated as in those first mentioned, germination tests were made in the greenhouse.

The results of the germination tests show that none of the pots contained any viable seeds. Of this latter group only the pots containing the *Asparagus officinalis* and *Bromus racemosus* (Nos. 32 and 33) showed remains of old sprouts. The seeds in the other pots apparently had all decayed without any germination during the time they were buried. The germination of the asparagus seed had been almost perfect. The pot buried at the greatest depth contained only a mass of sprouts, many of which were still partially alive. The *Bromus racemosus* showed that germination had taken place only in the pots buried at 6 to 8 and 36 to 42 inches, while those buried at the depth of 18 to 22 inches had all decayed before germinating.

It is interesting to note in this connection the behavior of the two species of Bromus—*Bromus secalinus* (cheat or chess) and *B. racemosus* (upright chess). The seeds of both of these species had completely lost their vitality within the eleven months in the soil, while the control samples gave a germination of 95.5 and 92.5 per cent,

respectively. These differences are more clearly shown in Plate I, A and B.

The results above stated, while perhaps not altogether conclusive, inasmuch as they represent only single tests of 200 seeds in each case, show that seeds of these two plants will not remain viable for long periods when buried in the soil.

This is particularly interesting in the case of the common cheat or chess, which is frequently a pernicious weed in the grain fields of the United States. The generally accepted opinion is that the grains of cheat will live in the soil for a number of years, the seeds germinating when conditions are most favorable, the resulting plants then crowding out the wheat. Some people even hold that in "off seasons" wheat turns to cheat, but fortunately such erroneous ideas are fast disappearing.

The results of these experiments show that cheat, whenever found growing in grain fields or elsewhere, has come from seed recently sown and has not been lying dormant in the soil. With but few exceptions the unexpected appearance of cheat comes either from seeds that have been sown unintentionally mixed with wheat or other grains so that they passed unobserved, or from seeds that have been scattered with stable manure.

Dr. Beal[a] has also shown that buried seeds of *Bromus secalinus* do not retain their vitality for a long period of years. In Beal's experiments the first test was at the expiration of five years, but not a single grain of cheat responded to the germination test at that time.

Table II includes the majority of our more commonly cultivated plants of the field or garden, all of which failed to show any seeds capable of germination after having been buried in the soil for approximately one year. This statement will hold good for the majority of our cultivated plants. There are, however, a number of exceptions. Many of these will be found in Table III, some showing that vitality was remarkably well preserved. Of these celery, parsnip, and tobacco (numbers 94, 95, and 99, respectively) should be mentioned in particular. The highest germination in each case was 64 per cent for the celery from the 18 to 22 inch depth, 63 per cent for the parsnip from the 36 to 42 inch depth, and 70 per cent for the tobacco from the 18 to 22 inch depth.

[a] Bulletin No. 5, Michigan Agricultural College, 1884.

TABLE III.—*Results of tests of seeds that had not completely lost their vitality while buried.*

Sample number.	Laboratory test number.	Kind of seed.	Chamber tests.			Greenhouse tests in sand.			
							Depth of burial.		
			Temperature.	Original sample.	Control.	Control.	6–8 inches.	18–22 inches.	36–42 inches.
			° C.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
38	16185	Festuca elatior	20–30	97	83	86	0.5	0.0	a0.0
39	16257	Capsicum annuum	20–30	96	97	80	.0	.0	.5
40	16222	Brassica campestris	20	90.25	86	18.5	.0	.0	b.5
41	16239	Trifolium repens	20	84.75	42.75	86	.0	b1	.0
42	16240	Vigna catjang	20–30	82.5	59.5	70	.0	1	.0
43	16230	Lespedeza frutescens	20	15	c1	2.5	.0	.0	1
44	16246	Ascyrum hypericoides	30	1.5	.0	.0	1	.0	.5
45	16259	Lycopersicon lycopersicon	20–30	99.25	72.5	88	.5	1	.5
46	16179	Chaetochloa glauca	20–30	55.75	37.5	18	1	1	1
47	16242	Rhus glabra	20–35	.0	.0	.0	.0	.0	2
48	16268	Cucumis sativa	20–30	100	98.5	62	.0	1	3
49	16236	Trifolium pratense	20	89.75	73	85.5	2	4	4
50	16235	Trifolium hybridum	20	91.75	84	73	2	4	4.5
51	16274	Xanthium pennsylvanicum	30	50	.....	.0	.0	.0	.5
52	16229	Cassia marylandica	30	14.5	d98	20	3	3	5
53	16273	Ambrosia trifida	20–30	29	52.5	48	.0	b2	6
54	16237	Trifolium pratense (10964)	20	67.75	.....	70	4.5	b5	6
55	16219	Vaccaria vaccaria	20–35	e6.5	88	68	.0	b4	7
56	16251	Convolvulus sepium	20–30	4	2	24	2	4	7
57	16283	Rudbeckia hirta	30	65.5	78.5	74.5	6.5	6.5	7
58	16224	Erysimum cheiranthoides	20–35	52.5	42	14.5	2	b5	b8
59	16231	Medicago sativa	20	84.5	64.5	97	b2	b9	b9
60	16227	Thlaspi arvense	20–30	57.25	54.5	.5	b11	8	11.5
61	16261	Solanum nigrum	20–30	97.75	91	12	9.5	10.5	12.5
62	16213	Chenopodium hybridum	20–30	61	18.5	10.5	7.5	9.5	13
63	16253	Cuscuta polygonorum	20–30	12	8.5	55.5	11.5	10.5	13
64	16193	Sporobolus cryptandrus	30	2.25	3	.0	.5	1.5	13.5
65	16265	Plantago rugelii	20–30	3.75	5.5	67.5	12	12	13.5
66	16255	Verbena hastata	20–30	9	.5	.....	11.5	13	14
67	16220	Brassica nigra	20	1.5	13.25	34	10	b14	b14
68	16238	Trifolium pratense (hard)	20	13.75	9.25	18	b10.5	15.5	14.5
69	16184	Elymus triticoides	20–30	84	75	85	1.5	b3.5	b15.5
70	16187	Panicum virgatum	20–30	30.5	36.5	22	7	17	16
71	16174	Avena fatua	20–30	70.5	91.5	93.5	b9	b8	18
72	16211	Beta vulgaris	20–30	153	.....	90.5	7	19.5	20
73	16228	Potentilla monspeliensis	20–30	41	83	73.5	b9.5	16	21.5
74	16183	Elymus canadensis	20–30	93.5	95.5	81	.0	b7	b22
75	16190	Poa pratensis	20–30	90.75	87	59	16	22	24.5
76	16262	Verbascum thapsus	20–30	82.5	98	72.5	7	7.5	25.5
77	16182	Elymus virginicus	20–35	65.25	44	83	a2	b13.5	b25.5
78	16226	Sisymbrium altissimum	20	88.25	86.25	76	b10.5	17.5	26
79	16256	Verbena urticifolia	30	1.5	.0	56.5	23.5	24.5	26.5
80	16277	Carduus arvensis	20–30	56.75	68	5	21	22.5	28.5
81	16292	Ipomoea lacunosa	20–35	98.5	f88	88	20	25	33
82	16254	Cuscuta epilinum	20–30	.0	.0	.5	15.5	23.5	34
83	16214	Amaranthus retroflexus	20–30	94.75	91	61	18	22	35
84	16276	Bidens frondosa	20–30	75	52.5	25	29	33	36
85	16225	Neslia paniculata	20–35	96	97	68	23	24.5	38.5
86	16216	Portulaca oleracea	35	83.75	91.5	16	39	38.5	30.5
87	16272	Ambrosia artemisiaefolia	20–30	58.5	42.5	30.5	32	37	41
88	16263	Plantago lanceolata	30	82.5	78	67.5	41	41	41
89	16279	Grindelia squarrosa	20–30	25.75	41	87.5	30.5	36	42
90	16271	Taraxacum erythrospermum	20–30	85.75	87.5	85.5	35.5	41.5	45.5
91	16264	Plantago major	20–30	24	78	.0	39.5	43.5	46.5
92	16278	Chrysanthemum leucanthemum	20–30	96.25	91	85.75	b21	b33	b49.5
93	16188	Phalaris arundinacea	20–35	69.25	8	78	45	46.5	56.5
94	16248	Apium graveolens	20–30	88	83.5	72.5	48.5	64	60
95	16249	Pastinaca sativa	20–30	55.5	67	78.5	29	51	63
96	16212	Chenopodium album	20–30	67.25	58	33.5	32	63.5	64.5
97	16280	Helianthus annuus (wild)	20–30	100	97	86	43.5	64	66.5
98	16269	Lactuca scariola	20	.25	11.5	83	63.5	69	69.5
99	16260	Nicotiana tabacum	20–30	89.25	81.25	89.25	46.5	70	55
100	16173	Agropyron repens	20–30	80.24	84	23.5	20.5	b73	66.5
101	16275	Arctium lappa	20–30	99.75	96	88.5	42.5	63.5	73
102	16209	Rumex obtusifolius	20–30	97.5	95.5	80	73	72.5	79.5
103	16208	Rumex crispus	20–30	80.75	83.5	91	67.5	79.5	79
104	16215	Phytolacca americana	20–30	40.5	d88.5	84.5	7.5	66.5	80.5
105	16250	Fraxinus americanus	20–30	49.5	2	26	.0	.0	84
106	16258	Datura tatula	20–30	99	d54	88	b86	84	86.5
107	16207	Rumex salicifolius	20–30	98.25	96.5	2.5	88.5	85.5	70.5
108	16178	Chaetochloa verticillata	20–30	92.75	94.5	88.5	b58	71	90
109	16282	Onopordon acanthium	20–30	95.5	31	.0	86	93	90.5

TABLE III.—*Results of tests of seeds that had not completely lost their vitality while buried*—Continued.

Sample number.	Laboratory test number.	Kind of seed.	Chamber tests.			Greenhouse tests in sand.			
							Depth of burial.		
			Temperature.	Original sample.	Control.	Control.	6–8 inches.	18–22 inches.	36–42 inches.
			° C.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
110	16218	Alsine media	20–30	97	98.5	93	90.5	96.5	92.5
111[g]	16243	Abutilon abutilon							
112[g]	16189	Phleum pratense							
		Average percentage of germination		63.2	57.5	53.2	20.5	26.5	31

[a] Many had germinated and afterwards decayed.
[b] Fresh sprouts found when samples were taken up. These sprouted seeds were not thrown away, but were transplanted with the remainder of the sample and tested in sand in greenhouse, consequently those which produced seedlings are included in the percentages of germination given in the table. These fresh sprouts were found as follows:

Sample number.	Depth.	Sprouts.	Sample number.	Depth.	Sprouts.	Sample number.	Depth.	Sprouts.	Sample number.	Depth.	Sprouts.
	Inches.			*Inches.*			*Inches.*			*Inches.*	
39	36–42	1	59	36–42	1	71	18–22	Many.	92	18–22	Many.
53	18–22	3	60	6– 8	1	73	6– 8	4	92	36–42	Many.
54	18–22	1	67	18–22	2	74	18–22	Few.	100	18–22	1
55	18–22	1	67	36–42	2	74	36–42	Many.	106	6– 8	2
58	18–22	10	68	6– 8	1	77	18–22	10	108	6– 8	Many.
58	36–42	5	69	18–22	Few.	77	36–42	5			
59	6– 8	4	69	36–42	Many.	78	6– 8	1			
59	18–22	2	71	6– 8	Many.	92	6– 8	Many.			

[c] Clipped seed germinated, 59 per cent.
[d] Clipped.
[e] Germinated, 84 per cent at 20° C.
[f] Clipped seed germinated, 100 per cent.
[g] Tests interrupted.

In Table III the names of the seeds are arranged in the order of their vitality as determined by the germination tests made in the greenhouse. The list of seeds tested begins with *Festuca elatior* (meadow fescue), which showed only one viable seed, that being from the 18 to 22 inch depth, and ends with *Alsine media* (common chickweed), in which nearly all of the seeds retained their power of germination throughout the entire period that they remained in the soil. The germination of the latter, when sown in the greenhouse, was almost perfect. (See Pl. II, fig. 1.)

In many instances some of the seeds had germinated while they were buried. In most cases the seeds which had germinated afterwards decayed. In the larger seeds this could usually be determined without much difficulty, but with many of the smaller seeds no such observations could be made. However, it is more than probable that many of the smaller seeds which showed a low germination when transplanted in the greenhouse had germinated and afterwards decayed before being dug up, but this could not be satisfactorily determined by a hurried field examination. Many of the pots also contained fresh

sprouts at the time the seeds were taken up. The number of fresh sprouts in each case is indicated in a footnote to Table III.

Unlike Table II, Table III includes names of but very few of our cultivated plants. The majority belong to that class of plants commonly known as weeds. These results show that but a limited number of our cultivated plants produce seeds which can retain their vitality for any length of time when buried in soil. On the other hand, the seeds of the plants which are commonly known as weeds are of strong vitality, and many of them deteriorated but very little with the treatment given. This, of course, is what we would expect. By natural selection the wild plants which survive are just those from seeds which are capable of living in the soil for a period of time more or less extended, and ultimately this factor becomes hereditary. With most of the cultivated plants the seeds are gathered and carefully saved from year to year, resulting in the loss of these inherited characteristics.

The mere fact that certain seeds retain their power of germination for a period of years when buried in the soil brands the plants which they produce as weeds. The length of time that such seeds can remain in the soil and still retain their power of germination largely determines their noxiousness. In other words, it may well be said that the pernicious character of weeds is directly proportional to the length of time the seeds will remain viable when buried in the soil. For this reason bad weeds are difficult to eradicate once the seeds are allowed to mature. (See Pl. II.)

RELATION OF DEPTH OF BURIAL TO VITALITY.

Table III shows that many of the seeds were better preserved the deeper they were buried. This is probably best explained by the difference in the three factors which govern germination, viz, *heat*, *moisture*, and *oxygen*. At the greatest depth the amount of moisture is always more uniform, the supply of air is greatly lowered, and the temperature is much reduced. The temperature decreases very rapidly as we go below the surface of the soil, and at 3½ feet is comparatively uniform throughout the year. Experiments conducted at McGill College, Montreal, Canada, by C. H. McLeod show that at a depth of 40 inches below the surface of the soil the minimum and maximum temperatures through the year were approximately 35° and 60° F., respectively.[a]

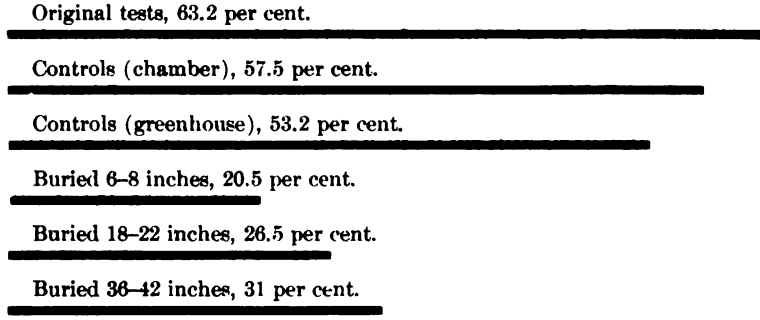
The greater number of seeds germinate best when subjected to daily alternations in temperature. These alternations do not take place at a depth of 3 feet below the surface; consequently there is a better

[a] Trans. Roy. Soc., Canada, Ser. 2, Vol. 7, Sec. III, pp. 13–16, 1901.

preservation of vitality at that depth as a result of the more dormant condition of the seeds. (See Pl. III and the diagram below.)

As was anticipated, most of the seeds which were stored in the Seed Laboratory preserved their vitality much better than those that were buried. But there are a number of cases in which the seeds were preserved practically as well in the soil as in the laboratory, the deterioration being very small in either case. However, with but few exceptions, an ample number of seeds remained germinable at the termination of the first year to produce plants in sufficient number to keep the up-to-date farmer busy for a good share of the summer in suppressing them. The average percentages of germination of all samples, including the original test and both controls, are best shown in the following diagram:

Average germination of controls and buried seeds.



HARD SEEDS.

An interesting point in these first results is in the behavior of the Trifoliums and closely related genera, including Lespedeza and Medicago. Generally speaking, these seeds are considered to be able to withstand very critical treatment, but the results of the first year's experiments show that the seeds of all of these deteriorated very greatly while in the soil.

The white clover, No. 41, germinated only 1 per cent, and showed one fresh sprout when taken up from the 18 to 22 inch depth and nothing from the shallower or deeper trenches. The red clover did but little better; No. 49, a sample of the harvest of 1902, germinated 2, 4, and 4 per cent for the three different depths of 6 to 8, 18 to 22, and 36 to 42 inches, respectively. Another sample of red clover, No. 54, germinated 4.5, 5, and 6 per cent, respectively, for the three different depths. A third sample of red clover, No. 68, germinated 10.5, 15.5, and 14.5 per cent, respectively, from the three depths. The last two samples were of Oregon-grown seed of the harvest of 1900. The original sample of this seed, No. 54, contained 51.5 per cent of

hard seed. No. 68 includes only the hard seed selected from the Oregon clover by soaking in water for 18 and then for 20 hours a portion of the original bulk sample, using only the remaining hard seed.

These results, while unsatisfactory, show clearly that it is the hard seeds in the clovers which remain over in the soil for some considerable time. The alsike clover, No. 50, behaved practically the same as the sample of red clover first mentioned. The Lespedeza, or bush clover, No. 43, gave results very similar to the white clover. The alfalfa, No. 59, gave a germination of only 2, 9, and 9 per cent, respectively, for the three different depths. But in all cases a few fresh sprouts were present when the seeds were taken up, showing that the seeds were germinating and afterwards decaying.

SEEDS OF CULTIVATED VERSUS WILD PLANTS.

A number of interesting cases showing the greater hardiness of the seeds of wild plants over those of like or closely related cultivated forms were recorded. In *Helianthus annuus* (Nos. 6 and 97) the seeds from the cultivated plant—our common sunflower of the garden—all decayed, while the seeds of the wild sunflower retained their vitality and germinated 43.5, 64, and 66.5 per cent, respectively, for the three different depths. Similarly with *Lactuca sativa* and *Lactuca scariola*, Nos. 5 and 98, respectively, the common garden lettuce seed had all decayed, while the seed of the prickly lettuce, possibly the parent of our cos varieties, germinated 63.5, 69, and 69.5 per cent, respectively, for the three different depths. Another striking example is in *Avena sativa*, No. 1, and *Avena fatua*, No. 71, the latter germinating 9, 8, and 18 per cent, respectively, for the three different depths, besides showing many fresh sprouts in the two shallower depths at the time the seeds were taken up.

Furthermore, it is not uncommon to find wide variations in different species of the same genus, even where all forms are wild, e. g., Elymus, Chaetochloa, Chenopodium, Cuscuta, Plantago, etc. But in the cases above mentioned of the cultivated and the closely related wild forms the ability of the seeds to withstand such treatment as being buried in the soil has been lost by long cultivation of the plants and the careful preservation of the seeds under artificial conditions or storage, while seeds from the wild forms can survive when buried in the soil, for it is the plants from just such seeds that have survived.

SUMMARY.

The length of time that seeds will retain their vitality when buried in the soil is of much importance in the extermination of weeds.

The seeds of many of our pernicious weeds can be destroyed by deep plowing, if the soil is left undisturbed for some time.

Seeds of the cultivated plants, with but few exceptions, lose their vitality when buried in the soil.

Seeds of the plants commonly designated as weeds retain their vitality remarkably well when buried in the soil.

In general, the pernicious character of weeds is directly proportional to the length of time the seeds will remain viable when buried in the soil.

The deeper seeds are buried, the better is vitality preserved.

Hard seeds of the same species retain their vitality much better than those with softer seed coats.

Unhulled seed, especially of the grasses, is more resistant than hulled seed, and the vitality is always better preserved.

Seeds of plants from the same genus often retain their vitality in a very different degree.

Vitality is best preserved, even in weed seeds, when the seeds are carefully harvested and stored in a dry and comparatively cool place.

PLATES.

DESCRIPTION OF PLATES.

PLATE I. Fig. 1.—*Bromus racemosus*, smooth brome grass. Fig. 2.—*Bromus secalinus*, cheat or chess. The two divisions at the right of each figure show the vigorous growth made by the check samples. In the three divisions at the left, A, B, and C, were planted the seeds which had been buried at depths of 6 to 8 inches, 18 to 22 inches, and 36 to 42 inches, respectively. The vitality of the seeds of these two species, which are considered as noxious weeds in the grain fields of the United States, was destroyed at the expiration of eleven months.

PLATE II. Fig. 1.—*Alsine media*, common chickweed. Fig. 2.—*Rumex crispus*, curled dock. Fig. 3.—*Datura tatula*, jimson weed. Seedlings from weed seeds which did not lose their vitality by burial for eleven months, as shown in the three divisions at the left of each flat, the germination being practically the same as in the case of the two check samples shown at the right of each flat.

PLATE III. Fig. 1.—*Elymus canadensis*, nodding wild rye. A, buried 6 to 8 inches—all killed; B, buried 18 to 22 inches—only one seedling shows in the figure, but the total germination was 7 per cent, as given in the table; C, buried 36 to 42 inches—germinated 22 per cent; the two check samples at the right made vigorous growth, germinating 81 per cent. Fig. 2.—*Fraxinus americanus*, white ash. A, buried 6 to 8 inches, and B, buried 18 to 22 inches—all killed; C, buried 36 to 42 inches—germinated 84 per cent; the check samples germinated 26 per cent, but the seedlings had "damped off" before the photograph was taken. Fig. 3.—*Phytolacca americana*, poke. A, buried 6 to 8 inches—germinated 7.5 per cent; B, buried 18 to 22 inches—germinated 60.5 per cent; C, buried 36 to 42 inches—germinated 80.5 per cent; the two check samples germinated 84.5 per cent.

The illustrations show that in many cases the vitality of seeds is better preserved at a depth of 36 to 42 inches than at shallower depths.

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FIG. 1.—BROMUS RACEMOSUS (SMOOTH BROME-GRASS).

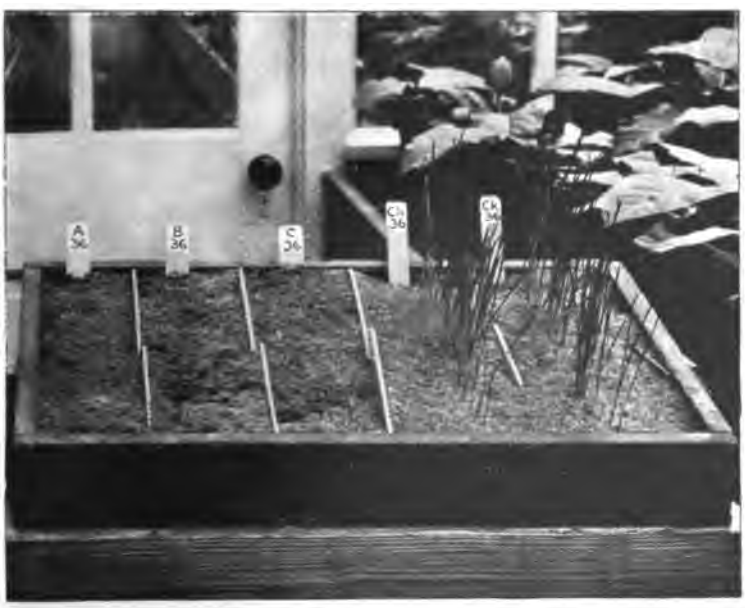

FIG. 2.—BROMUS SECALINUS (CHEAT, OR CHESS).

FIG. 1.—ALSINE MEDIA (COMMON CHICKWEED).

FIG. 2.—RUMEX CRISPUS (CURLED DOCK).

FIG. 3.—DATURA TATULA (JIMSON WEED).

FIG. 1.—ELYMUS CANADENSIS (NODDING WILD RYE).

FIG. 2.—FRAXINUS AMERICANA (WHITE ASH).

FIG. 3.—PHYTOLACCA AMERICANA (POKE).

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 84.

B. T. GALLOWAY, *Chief of Bureau.*

THE SEEDS OF THE BLUEGRASSES.

I. THE GERMINATION, GROWING, HANDLING, AND ADULTERATION OF BLUEGRASS SEEDS.

By EDGAR BROWN, *Botanist in Charge of Seed Laboratory.*

II. DESCRIPTIONS OF THE SEEDS OF THE COMMERCIAL BLUEGRASSES AND THEIR IMPURITIES.

By F. H. HILLMAN, *Assistant Botanist, Seed Laboratory.*

ISSUED NOVEMBER 14, 1905.

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1905.

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F. H. HILLMAN, *Assistant Botanist.* J. W. T. DUVEL, *Assistant.*

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., July 15, 1905.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 84 of the series of this Bureau the accompanying technical paper entitled "The Seeds of the Bluegrasses."

This paper was prepared by Mr. Edgar Brown, Botanist in Charge of the Seed Laboratory, and Mr. F. H. Hillman, Assistant Botanist, Seed Laboratory, and has been submitted with a view to publication.

The bluegrasses are among the most important forage plants in many sections of the United States and Europe, and large quantities of seed are harvested annually for use in this country and for exportation.

The process of cleaning the seed of the bluegrasses for market is such that many of the distinguishing characters are lost, and separate descriptions are necessary for the hand-picked and commercial seed of the same species.

The seeds of the different commercial species are so nearly alike in general appearance that at present none but the trained observer can distinguish between them. This similarity of appearance has encouraged the use of the cheaper and less desirable species, especially Canada bluegrass, for the adulteration of or substitution for the more expensive species.

The descriptions and illustrations herewith given of the bluegrasses and of their impurities will be of great value in furnishing seedsmen the necessary information to enable them to distinguish the different species.

The accompanying illustrations are necessary for a complete understanding of the text.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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B. P. I.—176.

THE SEEDS OF THE BLUEGRASSES.

I. THE GERMINATION, GROWING, HANDLING, AND ADULTERATION OF BLUEGRASS SEEDS.

By Edgar Brown,
Botanist in Charge of Seed Laboratory.

DESCRIPTION OF COMMERCIAL AND HAND-GATHERED SEEDS.

Great difficulty is experienced in distinguishing the seeds of the species of Poa. It is especially important to be able to recognize them, as the species vary greatly in value and the seed of one species is frequently substituted for that of another.

The descriptions of the seeds of Poa already published have been largely those of complete or hand-gathered specimens. But the seeds of some kinds as they appear on the market are more or less broken and have lost many of their distinguishing characters. The process of cleaning often rubs off the web at the base of the seed and the hairs along the sides and breaks the tip. On this account descriptions based on specimens of perfect seeds are not to be relied upon in identifying certain commercial Poas.

The mutilation of seeds during the process of cleaning is especially marked in home-grown seed of Kentucky bluegrass (*Poa pratensis*). Even the hand-gathered seed of rough-stalked meadow grass (*Poa trivialis*) is frequently so much injured about the slender apex as to increase greatly the difficulty of distinguishing it from that of Kentucky bluegrass. On the other hand, the commercial seeds of wood meadow grass (*Poa nemoralis*) and fowl meadow grass (*Poa triflora*) retain much of the pubescence on the glume, often the web, and are usually not broken on the tip.

It is important that descriptions and illustrations to be used in practical seed testing be taken from the commercial as well as hand-gathered seed and be comparative in character. Those given in this paper have been prepared from both hand-gathered and commercial seed. The term seed is here used in its popular sense.

GRADES AND QUALITY OF COMMERCIAL SEEDS.

The seeds of all species except Kentucky bluegrass are known to the American trade in only one grade. This is the so-called "fancy" grade, which is based on relative cleanness and on the bright appearance of the seed. The quality of different samples passing under this grade name is not necessarily uniform, but among the more careful dealers a purity standard of from 80 to 90 per cent is usually maintained.

The seeds of Kentucky bluegrass and of Canada bluegrass raised in this country are usually much cleaner and freer from foreign seeds than the European-grown seeds of rough-stalked meadow grass, wood meadow grass, and fowl meadow grass.

Kentucky bluegrass seed is commonly offered in two grades—"fancy," and "extra-clean" or "extra-cleaned." The latter names are a survival of the time when the seed was hand cleaned and the "extra-clean" was the best seed on the market. With the advent of improved machinery the "fancy" grade was established and it is now the only grade generally accepted by the intelligent purchaser. The "extra-clean" still on the market belies its name, since it consists of the chaff or cleanings from the fancy seed, and consequently contains only light seed. Samples of "extra-cleaned" as offered usually contain less than 10 per cent of seed.

In some cases the growers find a sale for the rough or uncleaned seed after it has been passed through a feed cutter. In this condition it has very much the appearance of fine-cut straw with a large percentage of chaff, and can be scattered over pastures and other areas, seeding them as effectually as could be done by the use of fancy recleaned seed. If well cured, the germinating quality of such seed is excellent, and the mass contains from 60 to 70 per cent of pure seed. Except for foreign trade the percentage of germination has little to do with the price and grade of bluegrass seed.

Aside from adulterated samples the purity of "fancy" seed of all species of bluegrass is usually good. Of the 2,887 samples of Kentucky bluegrass tested by the Zurich Seed Control Station from 1876 to 1903 the average purity was 86.3 per cent. Of the 69 samples tested in the Seed Laboratory of the Department of Agriculture during the past year the average purity was 75.02 per cent.

ADULTERATION.

The seed of Canada bluegrass (*Poa compressa*) is the only kind used as an adulterant of Kentucky bluegrass in this country. During the year 1904 649,451 pounds of Canada bluegrass seed were imported from Canada, practically none of which is being sold under its true name. Among the samples of seed sold for Kentucky bluegrass and sent to the Seed Laboratory for examination a large number have

contained from 30 to 50 per cent of Canada bluegrass seed and several have been entirely composed of the Canada seed.

It is significant in this connection that the price of Canada bluegrass seed varies with that of Kentucky bluegrass seed, being usually about one-half that of the latter. This adulteration is not merely a simple fraud by which the farmer pays for what he does not get, but the difference in the resulting pasture or hay crop is very important. Canada bluegrass, while having many good qualities in common with other species of Poa, is by no means a pasture grass, for which purpose Kentucky bluegrass is unexcelled.

The seed of wood meadow grass (*Poa nemoralis*) is sometimes adulterated with other species of Poa, and samples have been offered under this name that contain no wood meadow grass seed. One sample tested in the Seed Laboratory contained 59.4 per cent of *Poa pratensis* and 23 per cent of *Poa compressa*, the remainder being chaff and dirt. Samples of fowl meadow grass (*Poa triflora*) have been examined which consisted largely of various common grass and clover seeds combined with an abundance of weed seeds. These samples contained small quantities of Kentucky and Canada bluegrass seeds, much chaff and dirt, and some of them no seeds of fowl meadow grass.

The seed of Kentucky bluegrass is used to adulterate that of the higher priced *Poa trivialis*, pure seed of the latter species usually being hard to obtain. Some of the German authorities say that it is necessary for every farmer to save his own seed of this grass in order to be sure that it is pure. Hunter[a] says:

> Previously to 1883 good and genuine seed of this species (*Poa trivialis*) could not be obtained in this country [England]. Seed of the *Poa pratensis* was commonly supplied for it. It is now less difficult to procure genuine seed, but large quantities of seed of *Poa pratensis* (which usually costs about one-third the price) are prepared to resemble and are sold for *Poa trivialis*, and it is only by careful microscopic examination that the nature of the seed can be determined

WEIGHT PER BUSHEL.

The standard weight of a bushel of bluegrass seed of any grade is 14 pounds. The actual weight, however, varies from 6 to 8 pounds in the case of "extra cleaned" to 27 pounds or more for especially good samples of fancy recleaned seed. In the bluegrass region of Kentucky it is the usual practice to sell the seed fresh from the strippers or cured in the chaff by the bushel of 14 pounds, but it is always weighed, not measured. The cleaned seed is always sold by the pound. As the weight per bushel of bluegrass seed depends directly on its purity, it is customary in quoting the price of "fancy" seed to accompany it with a statement as to the weight per bushel.

[a] Treatise on Permanent Pasture Grasses, James Hunter. Chester, England, 1901.

The foreign trade is much more critical than the domestic trade, and the seed exported usually weighs from 22 to 24 pounds per bushel, while the domestic trade is content with seed weighing from 18 to 20 pounds. The heavier seed costs more per pound than the lighter seed, since there is more labor in its preparation, but it is cheaper for the purchaser.

GERMINATION.

The germination of commercial bluegrass seed is often poor. At the Zurich Seed Control Station the average percentage from 3,069 samples of Kentucky bluegrass seed tested from 1876 to 1904 was 65 per cent, while 908 samples of *Poa trivialis* tested showed an average of 72 per cent. The quality of Kentucky bluegrass seed as respects germination appears, however, to be improving. Last year's tests at the Zurich station gave an average of 68 per cent, while a few years ago 50 per cent was considered fair or satisfactory. Only the best seed goes to Europe, and consequently the percentage of germination of that offered in this country is low. As carefully cured seed will germinate from 80 to 90 per cent, the cause for the poor quality of commercial seed is doubtless to be found in the way it is harvested and cured.[a] The usual process is to pile the freshly stripped seed in ricks, either outdoors or in barns. This mass heats quickly if not stirred often during the first few days. One pile left without stirring reached a temperature of 140° F. in sixteen hours, killing all the seed.

GROWING AND HANDLING.

With the exception of our native western species, more or less seed of all the commercial Poas is gathered in Europe, where they are found wild. The harvesting is done by hand from the natural meadows, woods, or other uncultivated areas. The seed is cleaned by hand and carried to market in small quantities and collected by dealers who supply the trade. The United States furnishes Europe with Kentucky bluegrass seed, and Europe furnishes the seed of rough-stalked meadow grass and wood meadow grass, as well as of the other commercial species of Poa used in this country.

Poa pratensis (Kentucky bluegrass).—The bulk of the Kentucky bluegrass seed comes from a limited area known as the bluegrass region of Kentucky. The counties of Bourbon, Scott, Fayette, Clark, and Woodford furnish most of it, although there is a small quantity saved in Shelby County. Some is harvested in southwestern Illinois, and there is another area on the border between Missouri and Iowa where a considerable amount of seed is saved. The seed is gathered from the natural woodland pastures as well as from those where it has

[a] See Bulletin No. 19, Bureau of Plant Industry, "Kentucky Bluegrass Seed: Harvesting, Curing, and Cleaning."

been sown. It is customary to graze cattle on it nearly the entire year, as they do not materially injure the crop of seed if they are kept out for two or three weeks immediately before gathering. The seed is harvested by pulling the heads off with a stripper, the grass not being cut for hay. The cleaning is a rather difficult process, as it is necessary to rub the heads thoroughly in order to separate the seed from the web at the base. The last of the chaff and dirt which is blown out during the cleaning process is sold as "extra-cleaned" seed.

Poa compressa (Canada bluegrass).—The seed of Canada bluegrass is mostly produced in the Province of Ontario, along the north shore of the eastern half of Lake Erie. The soil is a heavy clay on limestone. In this section Canada bluegrass is not sown, but appears as a volunteer in any fields that are not kept under cultivation, making a thick growth and crowding out other grasses and weeds. It is nearly always found in wheat fields when the wheat crop is a partial failure. In this case the seed, ripening as it does at the same time as the wheat, is thrashed with it and screened out in cleaning. Where the seed is harvested alone the grass is cut with a mowing machine and cured the same as ordinary hay, and afterwards thrashed with a clover huller or grain separator. The hay is bright green, even when not cut until after the seed is ripe, and is well liked by some farmers as feed, while it is considered hard and of little value by others. A good crop is from 200 to 300 pounds of clean seed per acre. There has been some demand for this seed in the Southeastern States under the name of Virginia bluegrass. The seed is easily cleaned, as it is comparatively free from wool at the base and does not require rubbing, as does Kentucky bluegrass seed. No special machinery is used except rather long sieves to insure sufficient screening.

Poa trivialis (rough-stalked meadow grass).—The wholesale trade in the seed of rough-stalked meadow grass is largely confined to the city of Hamburg, Germany. The seed is collected in the neighborhood of that city and in the marshes of the Elbe. Seed of good quality is also supplied from Denmark, where in one locality this grass is grown especially for seed, and it is said to yield as much as 400 pounds to the acre. The seed is stripped or the grass is cut and the seed allowed to after-ripen, when it is cleaned by hand.

Poa nemoralis (wood meadow grass).—The seed of wood meadow grass is gathered by hand in the woods of Germany, and cleaned in the same manner as is the seed of *Poa trivialis*.

Poa triflora (fowl meadow grass).—Though widely distributed throughout the northern portion of the United States, this species is chiefly a natural meadow grass of lowlands, and is usually so mixed with sedges and other grasses that seed collection on a commercial scale has not thus far been undertaken in this country. The seed of this species on the market comes from Europe and is very poor.

Prof. L. R. Jones, of the Vermont Agricultural Experiment Station, reports the seed production from a nearly pure stand of this grass as amounting to 6 bushels of 19 pounds each per acre. A small plat yielded seed at the rate of over 7 bushels per acre. The seed is produced abundantly and ripens evenly. In Vermont it is harvested in the latter part of July. The name fowl meadow grass is often applied to another lowland grass, *Panicularia nervata.*

Poa arachnifera (Texas bluegrass).—The seed of Texas bluegrass is gathered by hand in northern Texas. It is cleaned by rubbing between the hands, and, owing to the long, woolly hairs at the base of the seed, it is never "fancy clean." The best seed is produced on rich, black, waxy soil, and is ripe about May 1 to 15. Only a small quantity is gathered each year, and consequently it is high priced and can not be considered as a commercial seed at the present time.

Poa annua (annual bluegrass).—The seed of the annual bluegrass is not on the market in this country, though the plant is common about dwellings, especially in the South and East, and ripens its seed throughout the summer. The seeds do not ripen evenly, the upper ones falling before the lower flowers have opened. The seed is gathered and used to some extent in Europe.

Poa alpina (alpine meadow grass).—Alpine meadow grass is best known in Switzerland, where the seed ripens from the end of June to the middle of July. The viviparous form can be propagated by scattering the buds during the hot weather.

Poa sudetica.—The seed of *Poa sudetica*, which is a European grass, is rare in the market, but is occasionally quoted by French and by German firms. It is sometimes mixed to some extent with the seeds of the meadow grasses, particularly water meadow grass (*Panicularia americana*).

In addition to the foregoing, other species of Poa occur in the western and northwestern United States, where they contribute to the native forage of the stock ranges. The seeds of these species, however, are not found in commerce.

II. DESCRIPTIONS OF THE SEEDS OF THE COMMERCIAL BLUEGRASSES AND THEIR IMPURITIES.

By F. H. Hillman,

Assistant Botanist, Seed Laboratory.

THE BLUEGRASSES.

The "seeds" of the species of Poa, or the bluegrasses, are the ripened florets or individual parts of the smaller clusters, or spikelets, of the general floral system of the plant. The number of florets in each spikelet varies from two to nine in the different kinds of Poa commonly found in commerce. There is some variation in the number of florets in the spikelets of each species. The florets separate readily at maturity, and well-cleaned samples of seed contain few whole or partial spikelets.

A complete, mature spikelet embraces, besides its several florets, a pair of chaffy scales, termed empty glumes, between which the florets, or at least the lower ones, rest. The empty glumes, while somewhat

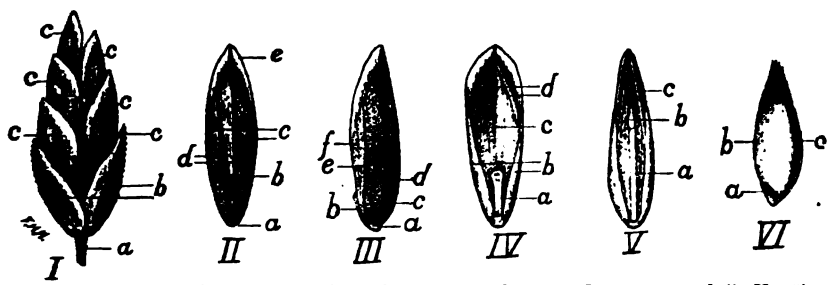

Fig. 1.—I.—A spikelet of Poa: *a*, stem of spikelet; *b*, empty glumes; *c*, florets, or "seeds." II.—Single floret, back view: *a*, callus; *b*, keel; *c*, intermediate veins; *d*, marginal veins; *e*, hyaline portion of glume. III.—Single floret, side view: *a*, callus; *b*, rachilla segment; *c*, keel; *d*, intermediate vein; *e*, marginal vein; *f*, margin of glume. IV.—Single floret, front view: *a*, rachilla segment; *b*, marginal fold; *c*, palea; *d*, keels of palea. V.—Terminal floret, front view: *a*, rachilla segment; *b*, aborted floret; *c*, palea. VI.—Caryopsis, or grain: *a*, location of embryo; *b*, keeled face; *c*, grooved face.

dissimilar, are keeled, acute, and one or three veined. The keel of each is usually hispid-ciliate above the middle. A portion of the stem of the spikelet often remains attached to the base of the empty glumes when these are found in commercial samples.

Each mature, well-developed floret or seed consists of a caryopsis, commonly called grain, two inclosing scales which, together with the empty glumes, constitute the chaff, and a slender appendage, the rachilla segment. (Fig. 1.)

The caryopsis corresponds to an individual grain in wheat, rye, and barley, and consists almost entirely of the seed proper, to which is added only the thin wall of the seed vessel. This is intimately blended with the seed coat, the two forming the covering of the true seed. The caryopsis is spindle-shaped and often broadest between the middle and the base. It is often bluntly keeled along one face and more or less evidently grooved along the opposite face. In the commercial bluegrass seeds the grain is amber-colored or dull wine-colored and semitranslucent. The surface is finely granular and dull. The kernel of the seed forms that part of the grain within the seed and seed-vessel walls. It consists of the embryo and endosperm, the latter forming the greater part. The embryo is situated at the basal extremity of the grain and is evident externally as a small ridge, often within a slight depression, on the keeled face. The grain adheres along its grooved face to the palea in some species in which free grains are not common in well-cleaned commercial seed.

The two chaffy scales of the floret differ chiefly in size, form, relative position, venation, and texture. The larger one, called the flowering glume or simply the glume, incloses the edges of the other, termed palea. The grain rests between the glume and palea, its keeled face lying against the glume. The rachilla segment is at the base of the palea and opposite the glume. It is one of the articulating sections of the rachilla, or axis of the spikelet.

The characters by which the different kinds of bluegrass seeds are distinguished one from another are afforded by the glume, palea, and rachilla segment, and involve size, form, color, veins of the glume, form and texture of the apex of the glume, and the pubescence.

The glume is stiffish and more or less pointed at the ends. Its base is marked by the presence of a small, somewhat knob-like appendage, the callus. The latter bears the scar of attachment of the floret and, in certain species, a more or less pronounced tuft of webby hairs. The back of the glume is more or less keeled along its longitudinal center. Besides the fold forming the keel, the edges of the glume are infolded along the marginal veins. The marginal folds often are most pronounced within and sometimes are confined to the lower half of the glume, in which event the upper margins usually diverge and become spreading or flaring at the apex. The keel is strongly arched lengthwise in some species and in others is nearly straight. Five veins traverse the glume longitudinally; one occupies the keel, two are at the marginal folds and are termed the marginal veins, while the other two are situated midway between the keel and marginal veins and are called intermediate or, by some authors, lateral veins. The intermediate veins exhibit considerable variation in distinctness in the different species. The vein occupying the keel extends to the apex. The apex and often the upper part of the lateral margins of the glume in

most species are thin and translucent, or hyaline. The extent of the hyaline portion of the apex has much to do with the form of the latter and is variable in the different species.

The palea is commonly more delicate in texture than the glume, being partially hyaline. It usually is shorter than the glume, but in some species equals or exceeds it in length. The difference in length usually is most evident in the lower florets of the spikelet. Two veins traverse the palea lengthwise and nearly meet at its apex. The margins of the palea are more or less acutely infolded along these veins, which are called the keels of the palea. The keels are mostly covered by the glume in some species, while in others they are almost wholly exposed. There is some variation in this respect, however, among seeds of the same species. The apex of the palea is often notched.

The rachilla segment is nearly cylindrical and usually somewhat curved. It is slightly expanded at the apex, which is obliquely truncate, its terminal surface constituting the scar of attachment to the succeeding floret. Different florets in the same spikelet in certain species exhibit a marked variation in the length of the rachilla segment, which is shortest in the lower florets and conspicuously longer in the terminal one, where it usually bears an aborted floret as a small, pointed appendage.

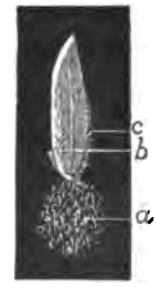

FIG. 2. — Unrubbed Kentucky bluegrass seed (*Poa pratensis*): *a*, web; *b*, pubescence of marginal vein; *c*, pubescence of keel.

The surface of the florets of different species of Poa is subject to considerable variation. Some florets are smooth, or glabrous; others bear numerous minute, stiffish hairs, rendering the surface rough, or scabrous; and some have a fine, appressed pubescence covering a part of the surface. Most of the species have a more or less silky pubescence on the keel and marginal veins below the middle or somewhat higher on the keel. The intermediate veins are more rarely pubescent. The keels of the palea are usually fringed with minute hairs, or are hispid-ciliate, but in some species they are silky pubescent. The basal web is wholly wanting in some species and in others varies from a few fibers to a copious tuft. It readily separates from the floret in most species. The rachilla segment is usually smooth, but in some species it is appressed pubescent. The presence of the hairs on the marginal veins often necessitates that care be used in examining the rachilla segment with respect to pubescence. (Fig. 2.)

The color of mature seeds varies from very light brown to dark brown. Sterile seeds are usually lighter or straw colored. Immature seeds are more or less tinged with green; some are purplish. In certain species the glume is tinged with golden yellow near the apex. The aborted terminal floret and all the hairs are white. The rachilla segment is lighter colored than the glume or palea.

Poorly cleaned samples are apt to contain many sterile florets. These are slender, sometimes shrunken, and usually lighter colored than the grain-bearing florets, which are comparatively plump and often dark colored, owing to the color of the grain appearing through the thin palea. (Fig. 3.)

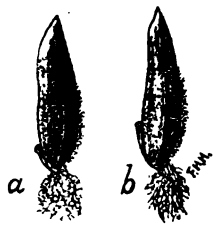

FIG. 3.—Seeds of Kentucky bluegrass (*Poa pratensis*): *a*, grain bearing; *b*, sterile.

The recognition of the several species of Poa, when the identity is questionable, requires the use of a good lens and a knowledge of the principal distinguishing characters. A sample under examination should be spread thinly on a sheet of paper, or, better still, on a black surface. With a good light and means for turning the seeds over while under the lens, they can easily be examined with reference to size, color, distinctness of veins, character of pubescence, the condition of the margins of the glume, etc. Exposing the different sides of the florets to the light while under examination is often absolutely essential in determining the nature of the veins and pubescence.

KEY TO THE SEEDS OF THE MORE COMMON SPECIES OF POA AS FOUND ON HERBARIUM SPECIMENS.

Basal web present.
- Web very persistent and conspicuous ..... *P. arachnifera.*
- Web easily removed, small; keel of the glume pubescent.
  - Intermediate veins distinct.
    - Intermediate veins sharply defined as narrow ridges; glume margins narrow, not easily seen from the side; marginal veins usually smooth. *P. trivialis.*
    - Intermediate veins usually not sharply defined; glume margins broader, easily seen from the side in fertile florets; marginal veins pubescent. *P. pratensis.*
  - Intermediate veins indistinct.
    - Rachilla segment smooth or nearly so; florets 2–2½ mm. long.
      - Florets usually broader above than below the middle; apex usually flaring; rachilla segment smooth ..... *P. compressa.*
      - Florets not evidently broader above than below the middle; apex usually golden yellow; rachilla segment sometimes rough ..... *P. triflora.*
    - Rachilla segment usually pubescent.
      - Florets 2½–3 mm. long, usually not yellow at the apex. ..... *P. nemoralis.*

Basal web not present.
- Florets strongly pubescent.
  - Intermediate veins distinct; palea keels prominent, often arched forward. *P. annua.*
  - Intermediate veins indistinct; palea keels not arched..... *P. alpina.*
- Florets not pubescent..... *P. sudetica.*

KEY TO COMMERCIAL BLUEGRASS SEEDS AFTER PREPARATION FOR MARKET.

Seeds *4–6 mm. long;* web longer than glume, forming a woolly tuft *and causing the seeds to cling in bunches in the sample* ..... *P. arachnifera.*

Seeds 2–2¾ mm. long, usually rubbed free from hairs and disconnected in the sample, *often more or less torn at the apex;* commonest commercial kinds.

Intermediate veins distinct; seeds contracted at the apex *and not wider above than below the middle;* hyaline margin of apex seldom present in rubbed seed. *P. pratensis.*

Intermediate veins very indistinct; seeds broader above than below the middle; hyaline margin of apex usually evident *and flaring* ..... *P. compressa.*

Seeds 2–3 mm. long, chiefly unrubbed; disconnected or clinging somewhat in the sample; usually not torn at the apex; smooth or the pubescence on the veins and the web more or less evident.

Intermediate veins indistinct.

Rachilla segment usually pubescent; long, sterile rachilla segments conspicuously common; *intermediate veins scarcely evident;* keel and marginal veins pubescent; apex of seed often flaring; seed 2½–3 mm. long ..... *P. nemoralis.*

Rachilla segment smooth; intermediate veins but slightly evident; keel and marginal veins pubescent; apex of seed sometimes flaring; *seed 2–2½ mm. long.* *P. triflora.*

Intermediate veins very distinct.

Rachilla segment smooth and slender; keel pubescent, marginal veins usually smooth; apex of seed acute and compressed; *seeds often distinctly curved as viewed from the side* ..... *P. trivialis.*

COMPARISON OF THE PRINCIPAL DISTINGUISHING CHARACTERS OF BLUEGRASS SEEDS.

Species.	Florets.				Glume.				Palea.	Rachilla segment.	Aborted floret.
	Number in the spikelet.	Length.	General form.	Apex.	Intermediate veins.	Silky pubescence.	Basal web.	Color.			
		mm.									
P. pratensis.	3–5	2–2¼	Lanceolate or ovate-lanceolate.	Acute, mostly torn in commercial seed.	Distinct; not sharply defined, slender ridges; smooth.	On keel and marginal veins; absent in commercial seed.	Well developed; absent in commercial seed.	From light brown to dark brown, often purplish.	Equal to or somewhat shorter than the glume; keels hispid-ciliate and more or less exposed.	⅓ to ½ the length of glume; smooth.	Minute.
P. compressa.	3–9	2–2½	Oblong-obovate or lanceolate.	Usually obtuse; torn or flaring in commercial seed.	Indistinct or apparently wanting; smooth.	Same as in *P. pratensis.*	Slight; absent in commercial seed.	Straw-colored or light brown, sometimes purplish.	Same as in *P. pratensis.*	⅓ to ½ the length of glume; smooth.	Minute.
P. trivialis.	2 or 3	2–2½	Narrowly lanceolate, often curved.	Acute; usually hyaline-edged and entire; distinctly keeled.	Sharply defined as slender ridges; smooth.	On keel; marginal veins smooth; often present in commercial seed.	Slight; usually absent in commercial seed.	Light brown, sometimes purplish.	Same as in *P. pratensis.*	Very slender, ¼ to ½ the length of glume; smooth.	Minute.
P. nemoralis.	2 or 3	2½–3	Lanceolate or ovate-lanceolate.	Obtuse or acute; hyaline and often flaring.	Indistinct; smooth.	On keel and marginal veins; present in commercial seed.	Same as in *P. trivialis.*	Light brown, sometimes yellowish at the apex.	Same as in *P. pratensis.*	Slender, ¼ to ⅓ the length of glume; pubescent; long, sterile segments abundant.	Often as long as the rachilla segment.
P. triflora.	2–4	2–2½	Same as in *P. nemoralis.*	Acute or slightly flaring; hyaline.	Same as in *P. nemoralis.*	Same as in *P. nemoralis.*	Same as in *P. trivialis.*	Light brown, usually yellowish at the apex.	Same as in *P. pratensis.*	Slender, ¼ to ⅓ the length of glume; smooth or rough.	Often long.

P. arachnifera.	4 or 5	4–6	Narrowly lanceolate.	Acuminate; hyaline-edged; not flaring.	Usually distinct as narrow ridges; smooth.	Same as in *P. nemoralis.*	Very copious; persistent; present in commercial seed.	Straw-colored or light brown.	Shorter than glume; keels hispid-ciliate.	¼ to ½ the length of glume; smooth.	Minute.
P. annua.	3–5	1½–3	Robust; ovate-lanceolate.	Acute or broadly flaring and hyaline.	Distinct; more or less pubescent.	On all the veins or only on keel and marginal veins; often on surface between the veins at base.	None.	From light brown to dark brown.	Equal to or shorter than glume; keels prominent, arched, pubescent.	Stout, ½ to ¾ the length of glume.	Minute.
P. alpina.	3–6	2½–3½	Obovate or ovate-lanceolate.	Acute or flaring, hyaline.	Indistinct or evident below the middle: smooth or pubescent.	On keel and marginal veins and on surface between the veins at base.	None.	Light brown, sometimes purplish and yellowish.	Equal to or shorter than glume; keels exposed, slightly pubescent and hispid-ciliate.	From minute to ¼ the length of floret; smooth.	Minute.
P. sudetica.	2 or 3	3–4	Lanceolate or ovate-lanceolate.	Acute or acuminate; keeled and merely hyaline-edged.	Distinct for nearly or quite their full length; scabrous.	None; veins and often the general surface scabrous.	None.	Light brown to dark brown, sometimes purplish.	Equal to or exceeding the glume, often separated from it at the apex.	½ to ¾ the length of floret; the sterile segment tapering.	Minute or sometimes conspicuous.

DESCRIPTIONS OF SPECIES.

Poa pratensis L.

KENTUCKY BLUEGRASS, JUNE GRASS.

Spikelets 3–5 flowered; florets 2–2¾ mm., rarely 3 mm., long, lanceolate or fusiform as viewed from the back, lanceolate or ovate-lanceolate as viewed from the side, mostly acute or the terminal floret sometimes acuminate at the apex, glabrous between the veins, varying from light brown to dark brown, sometimes tinged with purple, sterile florets lighter; glume usually sharply keeled quite to the apex and often strongly arched, particularly at the base; its marginal folds comparatively broad, extending from the base nearly or quite to the apex, becoming hyaline-edged above the middle in the lower florets, usually not expanded or flaring at the apex, the edges nearly meeting in sterile florets, separated and usually distended forward in fertile lower florets, often scarcely covering the palea keels of fertile terminal florets, the hyaline edge more or less torn away and the margins jagged at the apex in rubbed commercial seed; intermediate veins distinct and glabrous; keel and marginal veins silky pubescent below the middle or somewhat higher on the keel; basal web well develôped; pubescence and web wanting, except occasional traces of the former, in well-rubbed commercial seed; palea nearly or quite as long as the glume, its keels finely hispid-ciliate and usually covered for the greater part of their length by the margins of the glume; rachilla segment slender, glabrous, varying from about one-sixth of the length of the glume in the lower florets to one-half its length in the terminal one; aborted floret of the sterile rachilla segment minute; grain 1½ mm. long, somewhat keeled and grooved, often broadest below the middle, reddish brown or darker about the embryo, and semitranslucent. (Fig. 4.)

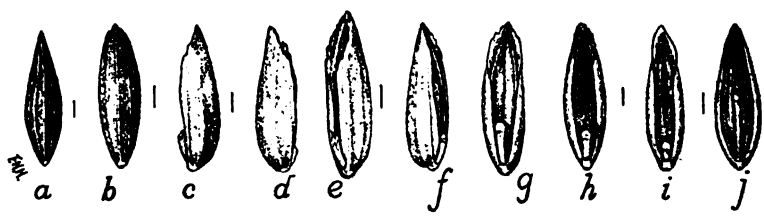

FIG. 4.—Different forms of commercial seeds of Kentucky bluegrass (*Poa pratensis*): *a* and *b*, back views; *c–f*, side views; *g–j*, front views; *j*, a terminal floret.

Commercial Kentucky bluegrass seed is mostly free from the silky and webby hairs present in hand-gathered samples, owing to the rubbing process to which it is subjected before being marketed. The severe rubbing results in more or less injury to the thin margins of the glume, particularly at the apex, which is usually found to be more or less torn when examined with a lens. Seeds of a well-rubbed sample do not tend to cling in small bunches as do those which are unrubbed or hand-gathered. Well-developed seeds are rather robust and have the glume margins well separated and evidently distended forward. Sterile seeds, or such as have the grain wanting or poorly developed, are generally lighter colored, slenderer, and more compressed, while the glume margins more nearly meet and are but slightly or scarcely distended. Such are much lighter in weight than well-developed seeds and consequently are mostly blown out with other chaff in well-cleaned seed.

Kentucky bluegrass seed is most readily confounded with that of Canada bluegrass (*Poa compressa*) and rough-stalked meadow grass (*Poa trivialis*). Owing to the difference in cost, *Poa compressa* is sometimes mixed with or substituted for Kentucky bluegrass, while the latter is sometimes similarly employed with respect to *Poa trivialis*.

The characteristic differences between Kentucky bluegrass seed and that of Canada bluegrass, as exhibited by the bulk samples and by individual seeds under the lens, may be compared as follows:

KENTUCKY BLUEGRASS (*Poa pratensis*).	CANADA BLUEGRASS (*Poa compressa*).
The usual, well-cleaned bulk samples are brown in color.	Average samples lighter colored than those of Kentucky bluegrass.
Individual, well-matured seeds exhibit the same brown color of the bulk sample.	The lighter color of individual seeds affords the principal character for the preliminary recognition of these seeds in mixtures.
Nearly all the seeds taper from the center to both ends and are not broader at the apex than at the base.	Most of the seeds are broader at the apex than at the base, often distinctly broader at the apex than at the middle.
The apex of commercial seeds is usually torn, obtusely pointed, keeled, and scarcely hyaline.	Apex of commercial seeds often torn, mostly expanded or flaring, often but slightly keeled.
The intermediate veins are almost invariably distinct.	The intermediate veins are very indistinct or apparently wanting.

A number of the samples of Kentucky bluegrass seed examined contained seed of the Canada bluegrass. As the latter seed found in commerce usually contains the prickles or even the seeds of Canada thistle (*Carduus arvensis*), these are often found in samples of Kentucky bluegrass seed containing the Canada bluegrass seed. Their presence indicates the admixture, since the Canada thistle does not grow in the seed-producing localities of Kentucky, while it is abundant in Canada, where the Canada bluegrass is produced. Samples of pure Kentucky bluegrass seed are apt to contain the prickles of horse nettle (*Solanum carolinense*), sometimes wrongly called bull thistle, a prickly plant common in the bluegrass region of Kentucky. These prickles are similar to those of the Canada thistle, but may be distinguished, as shown hereafter in this paper in describing the impurities of the bluegrass seeds. The fact that Canada bluegrass only begins to flower at the time Kentucky bluegrass is ripe precludes the possibility of the mixture of the two kinds of seed owing to the fact of growth together. Such mixture can occur only after the seed is gathered, through accident or intent.

Poa compressa L.

CANADA BLUEGRASS, FLAT-STEMMED BLUEGRASS.

Spikelets 3–9 flowered; florets 2–2½ mm. long, oblong-obovate or the terminal one lanceolate as viewed from the back, somewhat narrowly oblong as viewed from the side, obtuse or the terminal one acute, smooth between the veins, straw colored or light brown; glume somewhat arched, especially at the base, and strongly keeled at the back, the keel often less pronounced at the apex than at the base; margins infolded from the base for about three-fourths the length of the floret in the lower florets and nearly to the apex in the upper ones, hyaline-edged above the middle, often broadly so at the apex, which is more or less flaring in the lower florets, the thin apex often torn and jagged in commercial seed; intermediate veins very indistinct or not evident, glabrous; keel and marginal veins silky pubescent below the middle; basal web present, slight; palea nearly or quite equaling the glume, finely hispid-ciliate on the keels, which are usually more or less exposed above the middle, sometimes from the base; rachilla segment glabrous, varying from about one-fifth the length of the glume in the lower florets to one-half its length in the terminal one; aborted floret of the sterile rachilla segment minute; grain 1–1½ mm. long, keeled and slightly grooved, semitranslucent. (Fig. 5.)

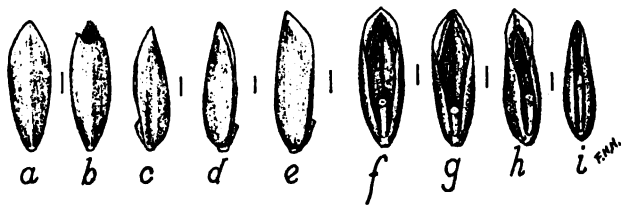

FIG. 5.—Commercial seeds of Canada bluegrass (*Poa compressa*): *a* and *b*, back views; *c–e*, side views; *f–i*, front views of florets; *i*, a terminal floret.

The seed of Canada bluegrass is the cheapest of the bluegrass seeds, and is therefore not adulterated with other Poas, although it is itself used as an adulterant to a considerable extent.

Pure samples of Canada bluegrass seed almost always contain the prickles and sometimes the seeds of Canada thistle (*Carduus arvensis*); therefore, the occurrence of these prickles with other kinds indicates the use of this species as an adulterant. Their occurrence with seed of *Poa trivialis* without evidence of the presence of Canada bluegrass seed is noted under the discussion of *P. trivialis*.

Poa trivialis L.

ROUGH-STALKED MEADOW GRASS.

Spikelets 2 or 3 flowered; florets 2–2½ mm., rarely 3 mm., long, narrowly lanceolate or the fertile terminal one ovate-lanceolate as viewed from the back, usually lanceolate and curved as viewed from the side, laterally compressed as compared with other species, straw colored or light brown and sometimes purplish, sharply keeled, the keel somewhat arched; margins of the glume scarcely or but slightly distended, narrowly and rather sharply infolded nearly or quite to the apex, which is hyaline-edged, very acute and rarely expanded; intermediate veins very distinct as narrow and sharply defined ridges; keel slightly pubescent below the middle, or rarely smooth; marginal veins smooth or sometimes pubescent, basal web present; palea nearly equal to the glume, its keels smooth or finely hispid-ciliate near the apex and mostly covered by the margins of the glume except in the larger terminal florets; rachilla segment very slender, glabrous, varying from one-fourth to one-half the length of the glume; grain 1–1½ mm. long, keeled and grooved, semitranslucent, reddish brown. (Fig. 6.)

Rough-stalked meadow grass is chiefly hand gathered; consequently the commercial seed is apt to bear more or less of the web as well as the silky pubescence on the keel. In many samples, however, both are rubbed away.

This seed resembles that of *Poa pratensis* and that of *Poa compressa* so closely that both are employed as adulterants, the former apparently to considerable extent, since it has frequently been found to constitute a considerable part of samples of so-called rough-stalked meadow grass. One sample examined marked "*Poa trivialis*" from Europe consisted almost wholly of *Poa compressa*. Several samples from Europe contained prickles of Canada thistle, but no seeds of Canada bluegrass were found.

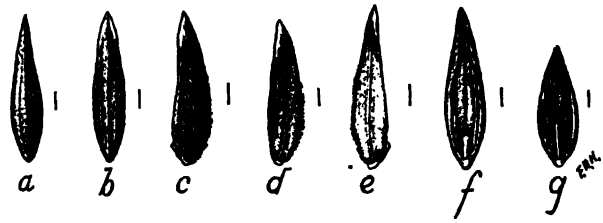

FIG. 6.—Seeds of rough-stalked meadow grass (*Poa trivialis*): *a* and *b*, back views; *c–e*, side views; *f* and *g*, front views; *g*, a terminal floret.

The principal distinguishing characters of the three species may be compared as follows:

ROUGH-STALKED MEADOW GRASS (*Poa trivialis*).	KENTUCKY BLUEGRASS (*Poa pratensis*).	CANADA BLUEGRASS (*Poa compressa*).
Commercial seeds are usually pubescent on the keel vein, usually smooth on the marginal veins and bear more or less of the webby hairs, consequently cling together in masses.	Commercial seeds rarely pubescent on the veins and the webby hairs wanting; consequently mobile in bulk, not clinging in masses; unrubbed seed pubescent on the marginal and keel veins.	
As viewed from the side, the seeds are somewhat curved, much narrower than the others, the glume margins usually only slightly evident.	Seeds mostly straight as viewed from the side, glume margins often strongly distended.	Seeds straight, the glume margins somewhat evident from the side.
Apex of the glume usually uninjured, strongly keeled, acute, slightly hyaline-margined, often curved.	Apex of the glume more or less torn in commercial seed; keeled, sharply pointed, hyaline-edged and not curved in unrubbed seed.	Apex of the glume often torn, otherwise somewhat keeled, obtusely pointed, broader than the base, hyaline-edged.
Intermediate veins sharply defined as narrow ridges.	Intermediate veins distinct as rather coarse ridges.	Intermediate veins indistinct or apparently wanting.
Rachilla segment very slender and less variable in length than in *P. pratensis* or *P. compressa*.	Rachilla segment coarser than in *P. trivialis* and often very short.	

Poa nemoralis L.

WOOD MEADOW GRASS.

Spikelets 2 or 3 flowered; florets 2½–3 mm. long, lanceolate or ovate-lanceolate, mostly acute at the apex, light brown, sometimes yellowish tinged near the apex; glume rather broadly keeled and somewhat arched at the back; margins of the glume narrowly infolded quite to the apex or hyaline-edged and often flaring above the middle; intermediate veins very indistinct; keel and marginal veins silky pubescent below the middle; basal web slight; surface between the veins glabrous; palea nearly equal to the glume, evidently shorter in florets having a flaring apex, its keels hispid-ciliate and usually covered by the margins of the glume; rachilla segment varying from one-fourth to three-fourths of the length of the glume, the sterile rachilla segment very uniformly much longer than the others, more or less appressed pubescent, the pubescence somewhat variable and sometimes nearly wanting; aborted floret of the sterile rachilla segment often one-half as long as the segment; grain 1½ mm. long, rather slender, semitranslucent. (Fig. 7.)

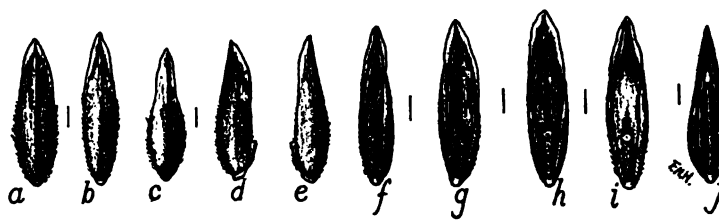

FIG. 7.—Seeds of wood meadow grass (*Poa nemoralis*): *a–c*, back views; *d* and *e*, side views; *f–j*, front views; *j*, a terminal floret.

Commercial wood meadow grass seed is not rubbed in preparation for market, and therefore possesses much of its rather persistent and prominent silky pubescence, and the thin tips of the florets are mostly uninjured. The pubescence of the rachilla segment is persistent and present in most of the seeds of all pure samples of this species. It affords the most marked characteristic by which the seeds of *P. nemoralis* may be distinguished from those of other commercial species of Poa. The conspicuously longer rachilla segments of the terminal florets are noticeably abundant in samples of this species, since these florets constitute from one-third to one-half of all the seed. The abundance of the long rachilla segments is helpful in distinguishing these seeds from those of other Poas.

Commercial seed of *P. nemoralis* is apt to be very much adulterated with other species of Poa. Of a number of samples examined less than half were true to name. One was nearly pure Canada bluegrass seed, and the rest consisted in part of one or all of the following species: *P. pratensis*, *P. compressa*, and *P. trivialis*.

The following comparison of characters should render it comparatively easy to distinguish the seeds of *P. nemoralis* from those of the other species.

WOOD MEADOW GRASS (*Poa nemoralis*).	KENTUCKY BLUEGRASS (*Poa pratensis*); ROUGH-STALKED MEADOW GRASS (*Poa trivialis*).	CANADA BLUEGRASS (*Poa compressa*).
Silky pubescence of the veins mostly present and prominent.	Silky pubescence of the veins wanting or but slight.	
Apex of the glume slenderly pointed or narrowly flaring.	Apex of the glume acute.	Apex of the glume broadly flaring.
Intermediate veins indistinct.	Intermediate veins distinct.	Intermediate veins indistinct.
Rachilla segment pubescent, often more than half the length of the glume.	Rachilla segment smooth, not exceeding half the length of the glume.	

Poa triflora Ehrh. (**P. flava** L., **P. serotina** Ehrh.).

FOWL MEADOW GRASS, FALSE REDTOP.

Spikelets 2–4 flowered; florets 2–2½ mm. long, lanceolate or ovate-lanceolate as viewed from the back, broadly keeled and strongly arched at the back, light brown and usually strongly tinged with yellow above the middle, sometimes purplish, margins of the glume narrowly infolded below the middle or quite to the apex, which is hyaline-edged, expanded but scarcely flaring; intermediate veins indistinct; keel and marginal veins silky pubescent below the middle; basal web slight; palea nearly or quite equal to the glume, finely hispid-ciliate on the keels, which are mainly covered by the glume margins in the lower florets; rachilla segment slender, glabrous or sometimes slightly scabrous, from one-fourth to one-half or two-thirds the length of the glume; aborted floret of the sterile rachilla segment often prominent and nearly as long as the rachilla segment; grain 1 mm. long, comparatively robust and smooth, scarcely keeled or grooved, semitranslucent. (Fig. 8.)

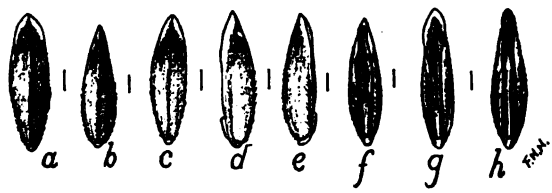

FIG. 8.—Seeds of fowl meadow grass (*Poa triflora*): *a–c*, back views; *d* and *e*, side views; *f–h*, front views; *h*, a terminal floret.

Most, if not all, of the seed of *P. triflora* on the market appears to be of foreign production. The samples examined have proved to be the worst found among the bluegrasses. It is probable that a better grade of seed could be secured from the natural meadows in this country where this species often constitutes the principal grass. The seeds of *P. triflora* are very similar to those of Canada bluegrass and wood meadow grass.

The principal distinguishing characters of the three kinds are as follows:

FOWL MEADOW GRASS (*Poa triflora*).	CANADA BLUEGRASS (*Poa compressa*).	WOOD MEADOW GRASS (*Poa nemoralis*).
Seeds 2–2½ mm. long.	Seeds 2–2½ mm. long.	Seeds 2½–3 mm. long.
Seeds mostly narrower at the apex than at the center.	Seeds mostly broader at the apex than at the center or base.	Seeds narrower or not broader at the apex than at the center.
Seeds usually yellowish at the apex.	Seeds not yellowish at the apex.	Seeds sometimes yellowish at the apex.
Intermediate veins usually evident but indistinct.	Intermediate veins indistinct or more commonly not evident.	Intermediate veins indistinct.
Pubescence of the veins and the web often present in commercial seed.	Pubescence of the veins and the web mostly absent in commercial seed.	Pubescence of the veins usually present in commercial seed.
Rachilla segment mostly smooth, sometimes slightly rough, often two-thirds the length of the glume.	Rachilla segment smooth, not exceeding one-half of the length of the glume.	Rachilla segment pubescent or sometimes only rough, often three-fourths the length of the glume.

The name fowl meadow grass is often applied, both by seedsmen and by writers upon grasses, to *Panicularia nervata*.

Poa arachnifera Torr.

TEXAS BLUEGRASS.

Spikelets 4 or 5 flowered; florets 4–6 mm. long, narrowly lanceolate, acuminate, straw colored or light brown; glume strongly keeled quite to the apex and somewhat arched; margins narrowly infolded below and becoming broadly hyaline above the middle, not widely flaring at the apex; marginal and keel veins strongly pubes-

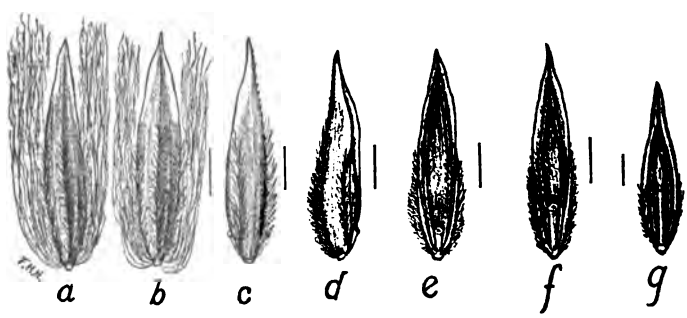

FIG. 9.—Seeds of Texas bluegrass (*Poa arachnifera*): *a* and *b*, back views, seeds showing the long hairs of the web; *c* and *d*, side views; *e–g*, front views; *g*, a terminal floret.

cent with long, silky hairs; basal web copious, often twice as long as the floret, very persistent; surface between the veins glabrous, the keel hispid-ciliate above the middle; palea from three-fourths to four-fifths the length of the glume, its keels more or less exposed, silky pubescent to the middle and hispid-ciliate at the apex; rachilla segment varying from about one-sixth to one-third the length of the glume, glabrous; aborted floret of the sterile rachilla segment minute; grain slender, 1½–3 mm. long, oblong-fusiform, nearly opaque, distinctly grooved and keeled. (Fig. 9.)

Texas bluegrass seed in commerce is unrubbed, and as the silky pubescence and web are very persistent they are always present. The hairs are so long and copious that the seeds cling in loosely matted, woolly bunches, and thus are easily distinguished from all the other commercial Poas. (Fig. 10.)

FIG. 10.—A cluster of Texas bluegrass seeds matted by the webby fibers.

Poa annua L.

ANNUAL MEADOW GRASS.

Spikelets 3–5 flowered; florets 1½–3 mm. long, ovate or ovate-lanceolate and relatively robust, strongly keeled and arched at the back, more or less densely pubescent, light brown or dark brown and often purplish or yellowish; margins of the glume very narrowly infolded below the middle, thin and broadly hyaline above the middle in the lower florets, flaring, gaping, or infolded at the apex; intermediate veins usually distinct as narrow ridges extending from the base to the margin of the apex, glabrous or pubescent; marginal veins and keel densely soft-pubescent below the middle; surface between the veins sometimes more or less pubescent at the base; web wanting; palea somewhat shorter than the glume, except in the terminal floret; keels of the palea coarse and prominent, mostly exposed, usually arched forward and exposed to side view in florets having a well-developed grain, often contracted toward the rachilla segment at the base, silky pubescent from near the base nearly to the apex; rachilla segment glabrous, from one-fourth to one-third the length of the glume, aborted floret of the sterile rachilla segment minute; grain 1–1½ mm. long, robust, distinctly granular, keeled and grooved, slightly translucent. (Fig. 11.)

The seed of *Poa annua* is not in the trade and is not apt to become mixed with the commercial bluegrass seeds. It may be readily distinguished from the common commercial species of Poa by its abundant

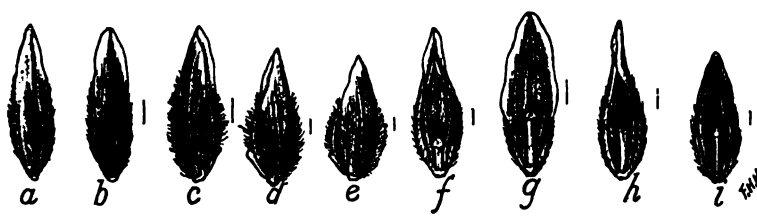

FIG. 11.—Seeds of annual meadow grass (*Poa annua*): *a* and *b*, back views; *c–e*, side views; *f–i*, front views; *i*, a terminal floret.

pubescence, arched and silky pubescent keels of the palea, and robust form. The seed most closely resembles that of *Poa alpina*, from which it is distinguished in individual seeds by its distinct intermediate veins and prominent, arched, and silky pubescent but not hispid-ciliate palea keels.

Poa alpina L.

ALPINE MEADOW GRASS.

Spikelets 3–6 flowered; florets 2½–3½ mm. long, ovate-lanceolate or obovate, the uppermost lanceolate, broadly keeled, arched, acute, or obtuse, light brown, sometimes purplish, and often yellowish tinged at the apex; margins narrowly infolded below the middle and becoming broadly hyaline at the apex; intermediate veins

indistinct or evident only below the middle; keel and marginal veins silky pubescent below the middle or higher on the keel, which is hispid at the apex; surface between the marginal veins and keel appressed pubescent at the base; web wanting; palea nearly or quite equal to the glume, its keels not arched as in *Poa annua*, slightly silky pubescent below the middle and hispid-ciliate above; rachilla segment glabrous, varying from no longer than wide to one-third the length of the glume; aborted floret of the sterile rachilla segment minute; grain 1½ mm. long, keeled and grooved, semitranslucent, dark reddish brown, granular. (Fig. 12.)

FIG. 12.—Seeds of alpine meadow grass (*Poa alpina*): *a* and *b*, back views; *c–e*, side views; *f–h*, front views; *h*, a terminal floret.

The seed of *Poa alpina* is not on the market and is not likely to be found in commercial seeds. Individual seeds of *P. alpina* closely resemble those of *P. annua*, but are to be distinguished by the indistinct intermediate veins of the glume, the variable rachilla segment, and especially by the keels of the palea, which are slenderer, not arched, less pubescent, and strictly hispid-ciliate above. The plant is alpine and occurs in the northern part of the United States as far west as Colorado, in Canada and Alaska, and in Europe and Asia.

Poa sudetica Haenke.

Spikelets 2 or 3 flowered; florets 3–4 mm. long, lanceolate or ovate-lanceolate; apex acute or acuminate; glume somewhat arched and strongly keeled at the back, light brown or dark brown, sometimes tinged with purple; margins of the glume narrowly infolded below the middle, narrowly hyaline-edged above the middle and not flaring at the apex; all the veins distinct, never silky pubescent, usually hispid;

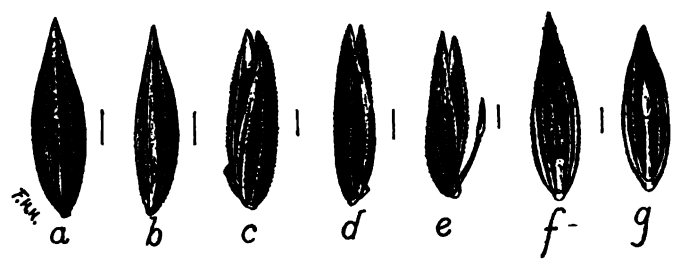

FIG. 13.—Seeds of *Poa sudetica*: *a* and *b*, back views; *c–e*, side views; *f* and *g*, front views; *g*, a terminal floret.

general surface scabrous or sometimes glabrous; web not present; palea equaling or somewhat exceeding the glume and often separated from it at the apex in florets having a well-developed grain; keels of the palea hispid-ciliate, mostly exposed and more or less evident from the side; rachilla segment varying from one-fifth to one-third or even one-half the length of the glume, glabrous or scabrous, sterile rachilla

segment tapering to the apex, the aborted floret usually minute, but sometimes conspicuous and nearly equal to the rachilla segment; grain about 2 mm. long, robust, light brown, slightly keeled and grooved, semitranslucent. (Fig. 13.)

This is a European species not found in the American market.

Panicularia spp.

Owing to the fact that *Panicularia nervata* is sometimes sold as fowl meadow grass, a description of its seed is presented. A description of the closely allied *P. americana*, which is often associated with *P. nervata*, is added as an aid in comparing the two species.

Panicularia nervata (Willd.) Kuntze.

NERVED MANNA GRASS, SOMETIMES CALLED FOWL MEADOW GRASS.

Florets 1–1½ mm. long, robust, ovate (obovate with reference to the plant), light brown, purplish and sometimes greenish when immature; glume rounded at the back, prominently seven-veined, its margins somewhat infolded at the base and not flaring at the apex, which is sometimes narrowly hyaline; surface smooth, except the veins, which are sometimes scabrous; palea equal to or sometimes longer than the glume, broad, the keels exposed, prominent and nearly meeting at the rounded and sometimes slightly notched apex, usually scabrous above the middle; rachilla segment one-fifth to one-fourth the length of the glume, subcylindrical and scarcely expanded at the apex, the terminal one somewhat longer than the others and tipped by a minute, aborted floret; grain loosely held by the stiffish glume and palea, obovate, slightly flattened, ¾–1 mm. long, smooth, somewhat polished, very dark brown or black, sometimes slightly translucent. (Fig. 14.)

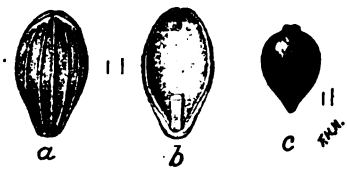

FIG. 14.—Seeds of nerved manna grass (*Panicularia nervata*): *a* and *b*, back and front views; *c*, grain.

Panicularia americana (Torr.) MacM.

REED MEADOW GRASS, WATER MEADOW GRASS, TALL MANNA GRASS.

Florets 3–3½ mm. long, elliptical-oblong as viewed from the front or back, somewhat spindle-shaped as viewed from the side, obtuse at the apex, brown, or purplish before complete maturity; glume rounded at the back, distinctly seven-veined, its margins narrowly infolded at the base and not flaring at the apex; surface smooth between the scabrous veins; palea equal to the glume, concave, its keels exposed, nearly meeting at the apex, very finely hispid-ciliate; rachilla segment one-fifth to one-fourth the length of the glume, subcylindrical, somewhat expanded at the apex, that of the terminal floret slightly longer and tipped by a minute, aborted floret; grain broadly oblong, 1½–2 mm. long, somewhat flattened, very dark brown, slightly translucent, smooth, and somewhat polished when fully developed. (Fig. 15.)

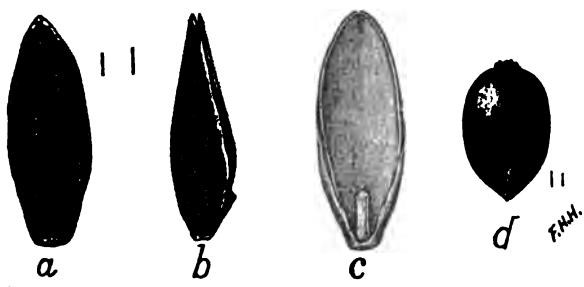

FIG. 15.—Seeds of water meadow grass (*Panicularia americana*): *a*, *b*, and *c*, back, side, and front views of seeds: *d*, grain.

WEED SEEDS COMMONLY FOUND WITH COMMERCIAL BLUEGRASS SEEDS.

The following weed seeds are those most frequently found with th various kinds of bluegrass seed.

Bursa bursa-pastoris (L.) Britton.

SHEPHERD'S-PURSE.

Seeds ¾–1 mm. long, oval-oblong, one extremity often pointed by the whitish tissu of the scar, flattened with rounded edges; faces similar and usually presenting two sha low grooves; color yellowish or reddish brown usually darker near the scar; surface nearl smooth; endosperm absent; embryo curve upon itself, the cotyledons incumbent; seed developing a coat of transparent mucilag when placed in water. (Fig. 16.)

FIG. 16.—Seeds of shepherd's-purse (*Bursa bursa-pastoris*): *a*, side view; *b*, edge view; *c*, natural size of seeds.

Seldom found abundantly, but occurring frequently in all of the commercial bluegrass seeds.

Lepidium virginicum L.

PEPPERGRASS.

Seeds 1½ mm. long, much flattened, ovate with one edge straight and thicker than the other, the curved edge narrowly margined, the margin usually hyaline and broadest at the broad end of the seed; faces similar, each nearly crossed lengthwise by a curved groove; scar at the small extremity, marked by a small, whitish tissue; surface smooth, dull, and reddish yellow; endosperm wanting; embryo curved upon itself, the cotyledons accumbent; seeds developing a copious coat of transparent mucilage when placed in water. (Fig. 17.)

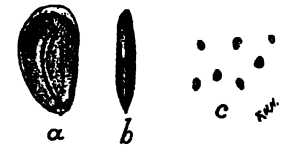

FIG. 17.—Seeds of peppergrass (*Lepidium virginicum*): *a*, side view; *b*, edge view; *c*, natural size of seeds.

Frequently found in home-grown seed and sometimes very abundant, especially in poorly cleaned seed.

Cerastium vulgatum L.

MOUSE-EAR CHICKWEED.

Seeds about ½ mm. long, flattened but not thin, rounded or triangular, the broad edge rounded, the narrow edge notched; surface roughened by small tubercles or very short ridges, dull, and reddish-brown; embryo cylindrical, curved about the endosperm, its extremities nearly meeting at the notch in the seed coat. (Fig. 18.)

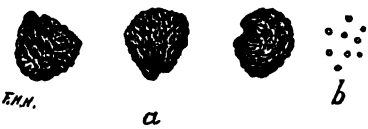

FIG. 18.—Seeds of mouse-ear chickweed (*Cerastium vulgatum*): *a*, side views; *b*, natural size of seeds.

Found frequently; sometimes abundant in poorly cleaned seed.

Alsine media L.

COMMON CHICKWEED.

Seeds circular-ovate, about 1 mm. in diameter with little variation in size, flattened with plane faces and flattened edges; scar in a small notch in the edge; surface dull, slightly tubercled, the tubercles in rows on the edges and in more or less evidently

concentric rows on the similar faces; color brown, or reddish in immature seeds: embryo cylindrical, curved about the endosperm, its extremities nearly meeting at the scar. (Fig. 19, *a*.)

Alsine media is very common in the United States, but is so low-growing that the American method of seed stripping prevents the occurrence of its seeds in abundance in commercial bluegrass seeds. Its seeds are common in European bluegrass seeds, particularly those of rough-stalked meadow grass.

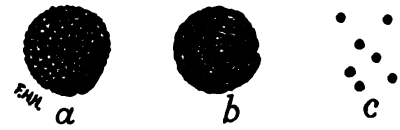

FIG. 19.—Seeds of chickweeds: *a*, *Alsine media*; *b*, *A. graminea*; *c*, natural size of seeds.

Alsine graminea (L.) Britton.

Seeds similar to those of *Alsine media*, except in form and surface markings; usually circular or oval; faces and edges somewhat rounded, finely roughened by short, interlacing ridges which are arranged more or less concentrically on the faces and parallel on the edges; surface dull; color grayish-brown, immature seeds reddish. (Fig. 19, *b*.)

Not found in American seed; frequent, although not abundant, in European seed.

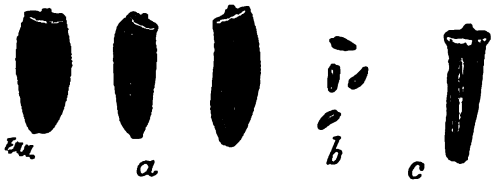

FIG. 20.—Seeds of Canada thistle (*Carduus arvensis*): *a*, well-matured seeds; *b*, natural size of seeds; *c*, a shriveled seed.

Carduus arvensis (L.) Robs.

CANADA THISTLE.

Seeds (akenes) 2–3 mm. long, oblong-lanceolate, flattened with obtuse edges, slightly ridged along each face, straight or curved edgewise, sometimes facewise; apex truncate, often obliquely so, concave with a ring-like border; corolla scar represented by a central, conical projection; surface dull and mostly smooth, sometimes with several narrow, longitudinal grooves; color brown, the apical margin usually lighter and sometimes yellowish. (Fig. 20.)

Prickles of Canada thistle and horse nettle (*Solanum carolinense*) often occur in certain bluegrass seeds. While the presence of the former is significant with respect to adulteration, the two kinds are apt to be confounded.

The prickles of Canada thistle are 2–6 mm. long, very slender, yellowish, usually expanded and laterally flattened at the base, which consists of a portion of the leaf tissue and is darker colored than the rest of the prickle, somewhat rounded or angular in form and jagged-edged. (Fig. 21, *c* and *d*).

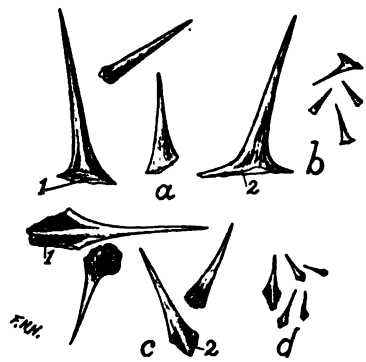

FIG. 21.—Prickles often found with bluegrass seed: *a* and *b*, horse nettle (*Solanum carolinense*) enlarged and natural size; *c* and *d*, Canada thistle (*Carduus arvensis*) enlarged and natural size; 1 and 2, characteristic forms of the bases of the two kinds of prickles.

The prickles of horse nettle (*Solanum carolinense*) are coarser, 4–8 mm. in length, light yellow in color, usually not darker at the base. They are produced on the stems and the coarse midribs of the leaves, and on breaking off have a transversely flattened scar. They occur frequently in samples of Kentucky-grown *Poa pratensis* and are easily mistaken for those of Canada thistle. (Fig. 21, *a* and *b*.)

Matured seeds, shriveled seeds, and prickles from the leaves and stems of Canada thistle are frequently found in Canada bluegrass seed. The presence of the prickles

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in the more expensive kinds of bluegrass seed indicates the probable use of Cana bluegrass seed as an adulterant. These prickles have been found, however, in roug stalked meadow grass seed in which no trace of Canada bluegrass seed appeare Owing to the troublesome nature of Canada thistle. care should be taken not introduce its seeds with those of the bluegrasses.

Taraxacum taraxacum (L.) Karst.

DANDELION.

FIG. 22.—Seeds of dandelion (*Taraxacum taraxacum*): *a*, side views; *b*, natural size of seeds.

Seeds (akenes) 3–4 mm. long, including the pe sistent base of the beak, which forms the point apex of the seed, lance-shaped or broadly s straight or curved, flattened or slightly fou angled with similar faces, barbed in the uppe broader half; teeth directed toward the ape: prominent on the edges and arranged in abo five rows on each face, which has two slend grooves with three rows of teeth between them; surface dull; color light brown c dark brown. (Fig. 22.)

Occurring occasionally in both American and European seed, these seeds hav appeared most frequently in Kentucky bluegrass and rough-stalked meadow gras seeds.

Matricaria inodora L.

SCENTLESS CAMOMILE.

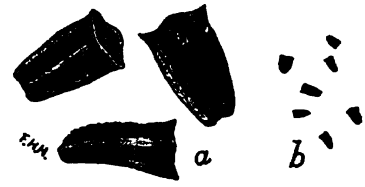

FIG. 23.—Seeds of scentless camomile (*Matricaria inodora*): *a*, back, front, and edge views; *b*, natural size of seeds.

Seeds (akenes) 1½–2 mm. long, slender or robust, oblong with obtuse extremities, tapering somewhat from the truncate apex to the base, slightly flattened; faces dissimilar, one having three prominent, longitudinal ribs joined at the apex, the lateral ribs and a partial one joined to them at the apex appearing on the opposite face, which also presents two small cavities separated by the partial ridge; surface between the ridges transversely roughened, dark brown or black and darker than the brown or yellowish ridges. (Fig. 23.)

Found only in foreign-grown seed, chiefly in rough-stalked meadow grass and wood meadow grass seeds.

Hieracium sp.

HAWKWEED.

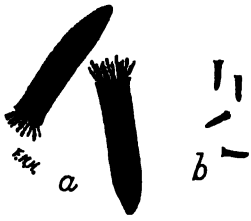

FIG. 24.—Seeds of hawkweed (*Hieracium* sp.): *a*, side views; *b*, natural size of seeds.

Seeds (akenes) 1–3 mm. long, cylindrical, pointed at the base; apex truncate, bearing a small tuft of short, whitish, marginal bristles (the remnants of the pappus bristles); surface lightly ten-ridged lengthwise; color brown or black, reddish in immature seeds. (Fig. 24.)

Found most frequently in wood meadow grass seed. The seeds of several species of hawkweed, occurring in both America and Europe, are practically indistinguishable. Specific determinations can not be made by examination with a lens. The troublesome character of orange hawkweed (*Hieracium aurantiacum*), whose seeds are 1¼–1¾ mm. long, justifies care in the use of seed containing seeds of any species of hawkweed.

Anthemis cotula L.

DOG FENNEL, MAYWEED.

Seeds (akenes) cylindrical, broadly club-shaped, 1½–2 mm. long, straight or curved; surface dull and usually roughened by many small tubercles more or less distinctly arranged in ten rows, indistinctly few-tubercled or nearly smooth, but commonly more or less evidently ten-ribbed; base tipped by the rounded, whitish scar; apex rounded or slightly pointed; color varying from light to dark brown. (Fig. 25.)

FIG. 25.—Seeds of dog fennel (*Anthemis cotula*): *a*, side views; *b*, natural size of seeds.

Found occasionally, but never abundantly, in both American and European bluegrass seed.

Chenopodium album L.

LAMB'S-QUARTERS, PIGWEED.

Seeds nearly circular, lens-shaped, with blunt edges, 1–1½ mm. in diameter, occurring in commercial seeds as free seeds or as fruits, the seeds proper being invested by the thin pericarp; free seeds jet black, smooth or nearly so, and highly polished; scar occupying a curved groove extending from the center to the edge of one face and usually evident as a light-colored line; fruits only slightly larger than the seeds, mostly gray or black and dull; pericarp wall often broken away, exposing the shining black surface of the seed; again, this wall and the seed coat are often broken, exposing the yellowish or whitish embryo and endosperm; embryo cylindrical, occupying the border of the seed and surrounding the endosperm, its extremities almost meeting, the tip of the caulicle occupying an extension of the seed coat at the edge beside the scar. (Fig. 26.)

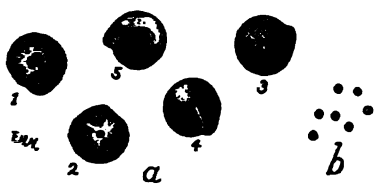

FIG. 26.—Seeds of lamb's-quarters (*Chenopodium album*): *a*, various forms of seeds; *b*, natural size of seeds.

Found chiefly in Kentucky bluegrass and Canada bluegrass seeds, but not frequently and never abundantly.

Plantago lanceolata L.

RIB-GRASS, BUCKHORN, ENGLISH PLANTAIN.

Seeds oval-oblong, 1¾–3 mm. long, flattened, one face convex, the other having a deep groove and rounded, infolded edges which scarcely meet at one end; surface smooth or slightly uneven, shining in fresh seed, brown or somewhat amber-colored; scar situated at the center of the grooved face; embryo straight, in the center of the endosperm, usually evident through the somewhat transparent endosperm and seed coat. When placed in water the seeds develop a coat of transparent mucilage. (Fig. 27.)

FIG. 27.—Seeds of rib-grass (*Plantago lanceolata*): *a*, front and back views of seeds; *b*, natural size of seeds.

Small seeds are found to some extent in both American and European seed; more commonly in Kentucky bluegrass than in Canada bluegrass seed.

Rumex crispus L.

CURLED DOCK.

Seeds (akenes) 1½–2½ mm. long, triangular with equal faces and broadly ovate-lanceolate; color dark reddish brown; surface smooth, polished; apex acute; base obtuse, contracted, and narrowly truncate at the scar; edges narrowly margined; faces longitudinally concave in poorly developed seeds; true seed coat thin; embryo cylindrical, resting in the center of one face of the endosperm; caulicle pointing to the base of the akene. (Fig. 28.)

FIG. 28.—Seeds of curled dock (*Rumex crispus*): *a*, broad and narrow forms; *b*, natural size of seeds.

Found occasionally, especially in Kentucky bluegrass and in Canada bluegrass seeds; small, imperfectly developed seed more commonly found than large, heavy seed. Their sharply three-angled, beechnut-like form distinguishes them from other impurities, except one or two other kinds of dock. The docks are destructive weeds, and care should be taken to prevent the sowing of their seeds.

Rumex acetosella L.

SHEEP'S SORREL, SORREL.

Seeds (fruits) acutely oval, three-angled, with equal faces, 1–1½ mm. long; represented in commercial seed by the seed-like akene only or by the akene covered by the thin, closely fitting perianth segments, which are six in number, three broad ones covering the sides of the akene and three small ones covering the angles at the base; covered by the perianth, the seeds are finely roughened, dull, and reddish brown; venation of the three broad segments evident; small segments at the basal angles often broken away; akenes but slightly smaller than when covered by the perianth, bluntly three-angled; surface smooth, somewhat polished, reddish brown or wine colored, often semitranslucent; angles dark at the apex; internal structure essentially the same as in *Rumex crispus*. (Fig. 29.)

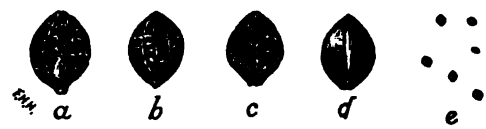

FIG. 29.—Seeds of sorrel (*Rumex acetosella*): *a*, *b*, and *c*, seed enveloped by the perianth; *d*, seed with perianth removed; *e*, natural size of seeds.

One of the commonest impurities in commercial seed, found in all seed of the cultivated bluegrasses.

Veronica arvensis L.

CORN SPEEDWELL.

Seeds ½–¾ mm. long, flattened and thin, more or less regularly oval, plane or sometimes curved facewise; center of the inner face marked by the relatively large, raised chalaza, which is united by a narrow ridge (the raphe) to the scar on the edge of the smaller extremity of the seed; external face slightly ridged longitudinally, indicating the position of the embryo, which is surrounded by the endosperm; surface dull, finely roughened by somewhat radially-disposed ridges, and reddish yellow. (Fig. 30.)

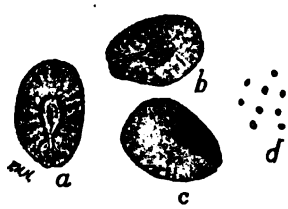

FIG. 30.—Seeds of corn speedwell (*Veronica arvensis*): *a* and *b*, front views; *c*, back view; *d*, natural size of seeds.

Found in bluegrass seed of various species, especially common in seed of Kentucky bluegrass. The relatively prominent chalaza and the radially uneven surface distinguish them from the seed of the closely allied *Veronica peregrina*, which sometimes occurs in commercial seed.

Juncus tenuis Willd.

SLENDER RUSH.

FIG. 31.—Seeds of slender rush (*Juncus tenuis*): *a*, seeds enlarged; *b*, natural size of seeds.

Seeds very minute, about ⅓ mm. long, broadly spindle-shaped, the extremities usually slightly curved; surface (as seen under a lens) nearly smooth; color reddish yellow, darker at the extremities, which sometimes bear a small white tissue. (Fig. 31.)

Often quite abundant in poorly cleaned Kentucky bluegrass seed, sometimes clinging in bunches of several seeds each.

Juncoides campestre (L.) Kuntze.

FIELD RUSH.

FIG. 32.—Seeds of field rush (*Juncoides campestre*): *a*, different views; *b*, natural size of seeds.

Seeds 1¼–1½ mm. long, oval, not flattened, the extremities unequally pointed, the basal extremity turned slightly to one side and consisting of soft white or yellowish tissue; a narrow and often indistinctly defined whitish ridge extends from the base to the apex; body of the seed wine-colored and semitranslucent or grayish. (Fig. 32.)

Found frequently in the seed of wood meadow grass and of the *Poa sudetica* of European origin.

Juncoides albida DC

WOOD RUSH.

Seeds 1–1¼ mm. long, narrowly oval, not flattened; base without an appendage of soft tissue; apex more acutely pointed than the base; a distinct brown or reddish brown ridge joins the base and apex; body of the seed reddish brown or wine-colored, often semitranslucent. (Fig. 33.)

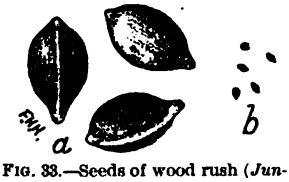

FIG. 33.—Seeds of wood rush (*Juncoides albida*): *a*, different views; *b*, natural size of seeds.

Found in various species of European-grown bluegrass seed. The usually smaller size, absence of the basal appendage, and more distinct and constant reddish-brown lateral ridge serve to distinguish these from the seeds of *Juncoides campestre*.

Carex cephalophora Muhl.

OVAL-HEADED SEDGE.

Seeds (akenes) 1½–2 mm. long, lens-shaped and broadly ovate, contracted at the base and tipped at the apex by a conical appendage (the base of the style); surface smooth and dull; color varying from light to dark brown; apical appendage often broken away in seeds found in commercial samples; perigynium broadly ovate-lanceolate, plano-convex, the tapering extremity usually rough-edged and notched at

the apex; surface sometimes slightly grooved or ridged lengthwise, otherwise smooth; color varying from light brown to greenish or dark brown. (Fig. 34.)

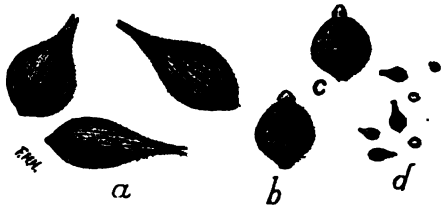

FIG. 34.—Seeds of sedge (*Carex cephalophora*): *a*, seeds inclosed by the perigynium; *b* and *c*, seeds with perigynium removed; *d*, natural size of seeds.

Seeds of sedge (Carex) are found in both American and European bluegrass seed. Owing to the wide area of their production, the seeds of various species of Carex occur in commercial bluegrass seed. The seeds of Carex are fruits (akenes) and occur free or inclosed within a sac-like covering (the perigynium). *Carex cephalophora* is the species most commonly found in Kentucky bluegrass seed.

ERGOT OCCASIONALLY FOUND IN COMMERCIAL BLUEGRASS SEED.

Claviceps purpurea (Fr.) Tul.

ERGOT.

This is a fungus growth affecting the grain (caryopsis) of many grasses. It is very common in the seed of redtop and other species of Agrostis, and occasionally occurs in bluegrass seed. The grain of the seed becomes elongated, extending beyond the glume and palea, attains about twice the length of the glume, and is club-shaped, straight, or, more commonly, somewhat curved. It is black, dull, and somewhat grooved lengthwise. (Fig. 35.)

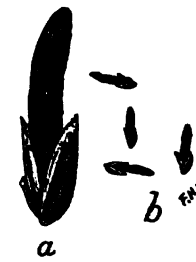

FIG. 35.—Ergot (*Claviceps purpurea*) of Kentucky bluegrass: *a*, enlarged; *b*, natural size.

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THE PHILADELPHIA
DEC 2 - 1905
MUSEUMS.

A FINE BED OF MUSHROOMS GROWN FROM SPAWN OF PURE-CULTURE ORIGIN.

THE FIELD MUSEUM
DEC 2 - 1905

U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 85.
B. T. GALLOWAY, *Chief of Bureau.*

THE PRINCIPLES OF MUSHROOM GROWING AND MUSHROOM SPAWN MAKING.

BY

B. M. DUGGAR,
PROFESSOR OF BOTANY IN THE UNIVERSITY OF MISSOURI, AND
COLLABORATOR OF THE BUREAU OF PLANT INDUSTRY.

VEGETABLE PATHOLOGICAL AND PHYSIOLOGICAL INVESTIGATIONS.

ISSUED NOVEMBER 15, 1905.

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1905.

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B. T. GALLOWAY,
Pathologist and Physiologist, and Chief of Bureau.

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[a] Detailed to Seed and Plant Introduction and Distribution.
[b] Detailed to Bureau of Chemistry.
[c] Detailed from Bureau of Chemistry.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., August 21, 1905.

SIR: I have the honor to transmit herewith a paper entitled "The Principles of Mushroom Growing and Mushroom Spawn Making," and to recommend that it be published as Bulletin No. 85 of the series of this Bureau.

This paper was prepared by Dr. B. M. Duggar, Professor of Botany in the University of Missouri and Collaborator with the Office of Vegetable Pathological and Physiological Investigations of this Bureau. Under the direction of the Pathologist and Physiologist, Doctor Duggar has been engaged for several years in the investigation of mushroom culture in all of its phases, and great advances have been made, especially in the production of purer and better spawns.

The accompanying illustrations are necessary to a complete understanding of the text of this bulletin.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

PREFACE.

The bulletin submitted herewith presents the results of the work up to the present time on the problems of mushroom culture and spawn making. The first publication on the subject from the standpoint of pure culture was Bulletin No. 16 of the Bureau of Plant Industry. This was followed by a Farmers' Bulletin (No. 204) on mushroom culture, presenting the results of our work for the use of the practical grower. As an outcome of the work Doctor Duggar has already accomplished, spawn of pure-culture origin is now being produced on a very large scale by several growers and is giving excellent results. This method enables the grower to improve and maintain the most desirable varieties of mushrooms in the same manner as is possible with other plants propagated from cuttings or buds. Information which would enable a grower to accomplish this has not been up to this time available. The general method of securing pure cultures as here described will enable the experimenter to cultivate spawn of other edible species of mushrooms in case it should be found desirable to cultivate them. The methods described differ radically from any hitherto used. They are of more general application and give far better results.

For the past three years this work has been carried on in cooperation with the University of Missouri, Doctor Duggar having left the Department to accept the professorship of botany in that institution. We wish to express our appreciation of the facilities furnished by the university for continuing this work.

ALBERT F. WOODS,
Pathologist and Physiologist.

OFFICE OF VEGETABLE PATHOLOGICAL
AND PHYSIOLOGICAL INVESTIGATIONS,
Washington, D. C., June 16, 1905.

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THE PRINCIPLES OF MUSHROOM GROWING AND MUSHROOM SPAWN MAKING

INTRODUCTION.

For a number of years there has been an increasing demand in the United States for information concerning mushroom growing. In the horticultural and agricultural press many individual practices have been presented; but in order to give rational encouragement to mushroom growing in favorable sections of this country it was recognized at the outset of the investigations undertaken by the writer that much experimental work would be required. Bearing upon the culture of *Agaricus campestris*[a] a number of physiological questions were demanding attention, for it was desirable to ascertain (1) the conditions of spore germination, in order that "virgin" spawn might be propagated and the principle of selection attempted; (2) the relation of this fungus to nutrients, or a determination of the substances or compounds which might best serve as food materials; and (3) the relation of the growing mycelium and of mushroom production to temperature, moisture, and other conditions of the environment. In the next place it would be necessary to determine the application of any physiological principles established to the practice of mushroom growing and mushroom spawn making.

In connection with a presentation of the results of the experimental work[b] it seems desirable to include also a more or less comprehensive account of the present status of mushroom growing at home and abroad.

[a] Throughout this paper the writer has employed the generic name *Agaricus* in the sense in which it is usually understood by those interested in the practical side of the work.

[b] During 1903–4 the writer was assisted in the experimental work by Mr. A. M. Ferguson, instructor in botany in the University of Texas, at that time special agent of the Department of Agriculture, and during 1904–5 similar assistance has been rendered by Mr. L. F. Childers, student assistant. Through the assistance thus given it has been possible to complete an unusual amount of experimental work, only a portion of which can be described in detail, although it has all been taken into consideration in the conclusions drawn.

It is not possible at this time to give more than a few brief suggestions concerning the possibility of cultivating other edible species than *Agaricus campestris*. The determination of the fundamental needs of diverse species will require study during a term of years.

GENERAL CONSIDERATIONS.

The propagation of *Agaricus campestris* does not seem to have been undertaken to any extent by the ancient Greeks or Romans. The occasional references to mushrooms in the classics are very general, as a rule, and do not suggest that artificial propagation was attempted. In the vicinity of Paris *Agaricus campestris* has been cultivated for several centuries, and the plants have certainly been sold on the open market quite as long.[a] It has not been possible to ascertain whether the methods now in vogue are essentially the same as those employed a few centuries ago. It is very probable, however, that the methods have been gradually improved. It would appear that the cultivation in caves is comparatively recent. The earliest records obtainable concerning the cultivation of mushrooms in the underground quarries indicate that this practice was not common previous to the nineteenth century.

Mushrooms are to-day extensively grown in England and France, and to a limited extent in Belgium, in Germany, and in many other countries. Paris remains, however, the center of commercial production. In the vicinity of that city the culture of mushrooms is now almost entirely confined to the underground limestone quarries or cement mines. The caves used for this purpose are termed "carrières" or "champignonières." These caves may consist of a labyrinth of galleries, or halls, ranging from 5 to 50 feet in width and from 5 to 30 feet in height. In some regions the earth is practically honeycombed by them, and the extent of the cave space used by the larger growers may be measured by miles. For the most part the ventilating system is perfect, every cave system possessing numerous air shafts, protected at the surface by wooden towers. Artificial partitions in the caves themselves enable the operator to control the ventilation. Until recent times the cultural methods have been more or less sacredly guarded by the growers, and even to-day it is not easy to get permission to make a casual visit to the champignonières. In many cases the work has been followed from generation to generation within the same family. There are at present, however, large corporations in control of some of the most famous caves.

[a] In a painting of the early seventeenth century (that of a Fishmonger's and Poulterer's Shop, by Jordaens and Van Utrecht, in the Gallery of Old Pictures, Brussels) *Agaricus campestris* and Boletus are shown on sale as a conspicuous part of a market scene.

In the United States fresh mushrooms have only recently been of any importance commercially, although florists and gardeners of English and French training have long been successful growers on a small scale. Nevertheless, during the past decade or so, the record of failures has been most conspicuous, and it is certain that of the many who attempted this work only a few, relatively, were uniformly successful.

The conditions under which mushrooms may be successfully grown are limited, and intelligent attention is therefore essential. It must be said, moreover, that the majority of failures may be directly traced to erroneous ideas as to the cultural requisites, or to a reckless disregard of conditions. The essential conditions will be subsequently defined in detail, but it may be stated here that failures are usually due to one or more of the following causes: (1) Poor spawn; (2) very poor manure; (3) unfavorable temperature; and (4) heavy watering during the early stages of growth.

Under suitable conditions mushrooms may be grown with assurance of success. Ordinarily they are grown only where the conditions may be controlled, and success should therefore be invariable.

MARKET CONDITIONS.

In the vicinity of Paris the mushroom industry has been remarkably developed during the past eight or ten years. The total product sold through the central market of Paris in 1898 was nearly 4,000,000 pounds; the quantity for 1900 is given as approximately 8,500,000 pounds, and for 1901 nearly 10,000,000 pounds. These figures show most convincingly the present status of the mushroom industry in France. It may be safely assumed that more than one-third of this quantity is consumed in a fresh state in and about the city. The growth of the canning industry during this period has also been remarkable. In 1898 about 1,800,000 pounds were preserved, while in 1901 the canned product amounted to nearly 6,200,000 pounds. During 1901 the approximate monthly production of mushrooms ranged from 651,000 pounds to 985,000 pounds, from which it is evident that these caves yield heavily throughout the year. In some instances growers are able to get a crop every four or five months.

It is extremely difficult to estimate the quantity of mushrooms grown in the United States. It is certain, however, that the production has increased very greatly, and particularly within the last four or five years. In the vicinity of several of our larger cities there are to-day individual growers who produce more than the total commercial output in the neighborhood of those cities ten years ago.

There is now a very good open market for fresh mushrooms in a few of the larger cities, although many large growers continue to

sell entirely by contract or by special orders to hotels and restaurants. With such an enormous comparative consumption of the canned product, there is every reason to believe that fresh mushrooms can be sold in much greater quantity as soon as this product becomes a certain factor in the market. With canning factories to take the surplus product, growers could afford to accept a smaller margin of profit, and this would place mushrooms within reach of many who may not be able to purchase them at present average prices. *Agaricus campestris* and its varieties and allied species are perhaps the only fresh mushrooms commonly salable in the markets of American cities. Throughout practically the whole of Europe several other species are legitimate market products. The more delicate or fleshy forms of the latter are sold as fresh mushrooms; others are dried, and some of these, being tougher, are used only for soups, sauces, and gravies. Besides the various species of truffle and morel, any special mention of which will be omitted here, the French market to-day legalizes the sale of five or six other species of mushrooms.

GERMINATION STUDIES.

Review of earlier work.—In a small way the germination of the spores of Basidiomycetes has received attention from the earliest times. A complete historical review of the literature dealing with spore germination will be found in Bulletin No. 16 of the Bureau of Plant Industry. It will be seen that most of the early work furnishes only incidental references to spore germination. By far the most important contributions made by early workers to this particular subject were several papers by Hoffmann.[a] It is not to be expected that the method employed by him would yield accurate results. Nevertheless, the work of Hoffmann is comprehensive for that time. Brefeld,[b] in his extensive reports upon the Basidiomycetes, gives the results of germination studies with a large number of the fleshy fungi. More than 200 species were used in his various experiments, and successful germination is recorded for about 160 species.

In 1898 the writer became interested in some attempts to germinate the spores of certain Basidiomycetes. Subsequently the problem received incidental attention in connection with some general studies on the physiology of spore germination.[c] The work progressed only

[a] Hoffmann, H. Ueber Pilzkeimungen. Botan. Zeitg., 19: 209–214, 217–219. 1859. Beiträge zur Entwickelungsgeschichte und Anatomie der Agaricineen. Botan. Zeitg., 18: 389–395, 397–404. 1860. Untersuchungen über die Keimung der Pilzsporen. Jahrb. f. wiss. Botanik, 2: 267–337. 1860.

[b] Brefeld, O. Botanische Untersuchungen über Schimmelpilze. Basidiomyceten, I, Bd. I, H. 3. 1877. Untersuch. a. d. Gesammtgebiete der Mykologie. Basidiomyceten, II, H. 7; III, H. 8. 1888–89.

[c] Duggar, B. M. Physiological Studies with Reference to the Germination of Certain Fungous Spores. Bot. Gaz., 31: 38–66.

far enough to suggest that an investigation of the factors influencing germination might yield studies of special interest. During 1900–1901 Dr. Margaret C. Ferguson undertook a systematic investigation of the relation of stimuli to germination in certain species. The results[a] have made it evident that the problems involved are not the well-known simple nutrient or physical factors. Miss Ferguson spent much time in experimenting with a great variety of nutrient media and special stimuli. Several thousand cultures were made. In the majority of these cultures *Agaricus campestris* was used, and it is shown that from the known ecological relationships of this fungus one could not possibly predicate the probable stimulus for germination. In fact, with no known nutrient medium or special chemical stimulus employed, was there anything more than erratic germination. Nevertheless, the work was finally very successful in the discovery that almost a perfect percentage of germination could be secured by the influence of the living hyphæ of *Agaricus campestris* upon the spores, as announced in the statement that "if a few spores are able to germinate under the cultural conditions, or if a bit of the mycelium of *Agaricus campestris* be introduced into the culture, the growth resulting will in either case cause or make possible the germination of nearly all the spores of the culture, provided, of course, that the other conditions are not such as to inhibit germination."

The stimulus would seem to be of enzymatic nature. No other mycelium tested produced a similar effect. This was a distinct advance in our knowledge of factors influencing germination. The stimulus, however, could only be looked upon as perhaps a substitution stimulus. It did not seem possible that it could obtain in nature, nor could it be looked upon as wholly satisfactory from a practical point of view.

Miss Ferguson's results offered encouragement; but, nevertheless, the problems with *Agaricus campestris* and related species were left open for further investigation. It should, perhaps, be emphasized that prior to 1902 no method had been published, so far as can be learned, whereby one might be able to obtain with uniformity the germination of *Agaricus campestris*. It is quite certain that Chevreul and others obtained at best only erratic results. Nevertheless, as early as 1893 Costantin and Matruchot[b] announced that a method had been developed by them whereby they were able to germinate the

[a] Ferguson, M. C. A Preliminary Study of the Germination of the Spores of Agaricus Campestris and Other Basidiomycetous Fungi. Bulletin No. 16, Bureau of Plant Industry, U. S. Dept. Agriculture, pp. 1–43. 1902.

[b] Costantin and Matruchot. Nouveau procédé de culture du champignon de couche. Compt. Rend. de l'Acad. des Sci., 117 (2): 70–72. (Compare, also, Bul. Soc. de Biol., 2 December, 1893.)

spores and to grow in pure culture the mycelium of *Agaricus campestris*. Information concerning the details of the method employed was avoided in the reports of this announcement and in subsequent references to the process.[a] In the first announcement the method is stated as follows:

Method followed.—The spores are collected free from contaminations, and in order to preserve them in that condition are sown on a certain sterilized nutritive medium. We obtain in this manner a twisted mycelium which constitutes pure spawn. By repeated cultures on an identical substratum the spawn can be multiplied indefinitely, and is transferred at a proper time to sterilized manure, where it develops abundantly in several weeks. At that stage it possesses the characteristic appearance and odor of natural spawn. It can then be sown in a bed of ordinary manure, to which it adheres and where it grows and fruits normally.

In the later paper cited, writing of the recent improvements in mushroom culture, Costantin expresses himself as follows:

We have succeeded in manufacturing an artificial spawn obtained from the spore germinated on a medium free from contamination. It is then pure spawn. We can state further that it is virgin spawn.

In 1897 Répin[b] claimed to have independently arrived at results similar to those obtained by Costantin and Matruchot. Concerning his germination studies he says:

It is only recently that the study of this question has been renewed, independently and simultaneously by Costantin and Matruchot.

There is nothing unusual in the germination of the spores of Agaricus. Spores can be germinated on media such as used in bacteriology, on wet sand, or in moist air as well as on manure. Without doubt, germination is not produced with the same spontaneity and rapidity as in the case of the spores of lower fungi, which fact makes it necessary to promote the process by some artifices, but they are only sleight-of-hand tricks, variable according to the operators, and which are acquired after some unsuccessful attempts. The spores which should germinate (and these are always in the minority) begin by swelling. This very simple method makes it possible to obtain virgin spawn at pleasure. It is applied industrially in the manufacture of spawn of Agaricus from cultures which I have made.

So far as the writer has been able to ascertain, therefore, no description of the method employed by the above writers is to be found. The report of Miss Ferguson's work is accordingly the only available scientific record defining the conditions under which germination had been constantly obtained up to this time.

Experimental work.—The writer has been able to confirm Miss Ferguson's work repeatedly, and at the same time numerous series of experiments have been made to test further the possibility of influenc-

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[a] Constantin, J. La culture du champignon de couche et ses récent perfectionnements. Extrait du Revue Scientifique. April, 1894.

[b] Répin, C. Le blanc vierge de semis pour la culture du champignon de couche. Revue Générale des Sciences. (September 15, 1897.)

ing germination by chemical stimuli. In distilled water, on the one hand, and in plant decoctions (such as decoctions of beans, sugar beets, mushrooms, potatoes, etc.) and in bouillon, on the other hand, there have been tested a large number of inorganic and organic salts, carbohydrates, nitrogenous compounds, and active enzymes.

The results of one series of experiments are tabulated in detail. In general, it has been found that dulcite, monobasic magnesium phosphate, magnesium phosphite, magnesium potassium ammonium phosphate, ammonium molybdate, magnesium lactophosphate, dibasic calcium phosphate, and other salts, especially phosphates, have in one medium or another been more or less effective as stimuli for germination. Unfortunately, none of the substances mentioned, apparently, are very strong stimuli; they are unable to cause invariable germination in all nutrient media. Moreover, in subsequent series, where the conditions have been the same, within experimental possibilities, wholly analogous results have not always been obtained. No account has been taken, however, of the particular variety of *Agaricus campestris* from which the spores were obtained, and it may be that this will influence the results.

It is to be noted from the following table that Miss Ferguson's method of employing living bits of mycelium was modified by the use of small pieces of the inner tissue of a young mushroom taken under sterile conditions. It was found that often a new growth of mycelium was developed from this tissue. Whenever this growth appeared, the influence upon spores in the drop culture was, as might be expected, the same as had been demonstrated for the living mycelium. Frequently a few spores germinated within from three to five days. The most interesting conclusion, however, which could be drawn from the cultures in which small bits of tissue were used was the following: Under favorable conditions a small piece of the inner growing tissue of a mushroom is capable of producing a mycelium with great readiness. This fact has been utilized, as shown in detail later, in the development of a new and effective method of securing pure cultures of fleshy fungi in general.

TABLE I.—*Extent of germination.*

No.	Media.	After 3 days.	After 5 days.
1	Distilled water	*a*—5 spores *b*—None	As before. Do.
2	Bouillon	None	None.
3	½ per cent KH_2PO_4	do	Do.
4	½ per cent KH_2PO_4 in bouillon	do	Do.
5	½ per cent K_2HPO_4	do	Do.
6	½ per cent K_2HPO_4 in bouillon	do	Do.
7	½ per cent Na_2HPO_4	do	Do.
8	½ per cent Na_2HPO_4 in bouillon	do	Do.
9	½ per cent $(NH_4)_2HPO_4$	do	Do.
10	½ per cent $(NH_4)_2HPO_4$ in bouillon.	do	Do.

TABLE I.—*Extent of germination*—Continued.

No.	Media.	After 3 days	After 5 days.
11	½ per cent $MgH_4(PO_4)_2$	10 spores	50 per cent.
12	½ per cent $MgH_4(PO_4)_2$ with bouillon.	*a*—1 spore *b*—None	3 per cent. None.
13	½ per cent $MgHPO_4$	None	Do.
14	½ per cent $MgHPO_4$ in bouillon	*a*—10 spores	1 per cent. Germinated spores badly injured.
15	½ per cent $Mg(NH_4)PO_4$	None	None.
16	½ per cent $Mg(NH_4)PO_4$ in bouillon.	2 spores	As before; injured.
17	½ per cent $MgK(NH_4)PO_4$	Few spores	5 per cent.
18	½ per cent $MgK(NH_4)H_2(PO_4)_2$ in bouillon.	do	Do.
19	½ per cent $(NH_4)_2C_4H_4O_6$	*a*—None *b*—None	Few spores. 10 per cent.
20	½ per cent $(NH_4)_2C_4H_4O_6$ in bouillon.	10 spores	As before; injured.
21	½ per cent magnesium lactophosphate.	do	5-10 per cent.
22	½ per cent magnesium lactophosphate in bouillon.	do	2-5 per cent.
23	½ per cent $Ca_2H_2(PO_4)_2$	None	1-2 per cent.
24	½ per cent $Ca_2H_2(PO_4)_2$ in bouillon	10 spores	Injured.
25	½ per cent $KCHO_2$	None	1-2 per cent.
26	½ per cent $MgHPO_3$	10 spores	10-50 per cent.
27	½ per cent $MgHPO_3$ in bouillon	do	1 per cent.
28	½ per cent $MgK(NH_4)H_2(PO_4)_2$ in mushroom decoction.	do	1-2 per cent.
29	½ per cent KH_2PO_4 in mushroom decoction.	None	None.
30	½ per cent K_2HPO_4 in mushroom decoction.	do	Do.
31	½ per cent Na_2HPO_4 in mushroom decoction.	Few spores	Injured.
32	½ per cent $(NH_4)_2HPO_4$ in mushroom decoction.	1 or 2 spores	Few spores.
33	½ per cent $MgHPO_4$ in mushroom decoction.	Few spores	2-5 per cent.
34	do	10-50 per cent	10-20 per cent.
35	½ per cent $Mg(NH_4)PO_4$ in mushroom decoction.	Few spores	Contaminated.
36	½ per cent $(NH_4)_2C_4H_4O_6$ in mushroom decoction.	2 per cent	Contaminated; 50 per cent, but injured.
37	½ per cent magnesium lactophosphate in mushroom decoction.	10 spores	3-5 per cent; injured.
38	½ per cent $Ca_2H_2(PO_4)_2$ in mushroom decoction.	5-8 per cent	10 per cent.
39	½ per cent $KCHO_2$ in mushroom decoction.	2-3 per cent	10-20 per cent.
40	½ per cent $MgHPO_3$ in mushroom decoction.	1-2 per cent	*a*—5 per cent. *b*—Contaminated
41	Decoction of mushrooms	*a*—2 per cent *b*—Very few spores	2 per cent. 1-2 per cent.
42	Living tissue of mushroom in mushroom decoction.	*a*—Few spores [a] *b*—None [b]	12 spores.
43	do	*a*—Few spores [a] *b*—None [b]	As before. None.

[a] In this cell the tissue developed a new growth.
[b] No growth from tissue introduced.

On account of the fact that magnesium phosphite and magnesium potassium ammonium phosphate had in most cases proved to be stimuli for germination, experiments were next made to determine the efficiency of these salts on various media, as indicated in the table on the following page.

TABLE II.—*Efficiency of salts on various media.*

Nature of compost.	Appearance after 25 days.	Nature of compost.	Appearance after 25 days.
Well-rotted stable manure.[a]	No growth.	Well-rotted cow manure.[b]	Good growth.
Do.[b]	Fine growth.	Peaty mold[a]	No growth.
Half-rotted stable manure.[a]	One, fair growth; one, good growth.	Do.[b]	Do.
Do.[b]	No growth.	Maryland peat[a]	Do.
Fresh stable manure[a]	One, good growth; one, slight growth.	Do.[b]	Do.
Do.[b]	One, good growth; one, fine growth.	Well-rotted Ginkgo leaf mold.[a]	Do.
Well-rotted cow manure.[a]	One, good growth; one, slight growth.	Do.[b]	Do.
		Cotton-seed motes[a]	One, no growth; one, fine growth.
		Do.[b]	Fine growth.

[a] Watered with concentrated solution of magnesium phosphite.
[b] Watered with strong solution of magnesium potassium ammonium phosphate.

Large test tubes were used in these experiments, and duplicate cultures were made in every instance. From these and from numerous other cultures it was ascertained that germination could not be obtained invariably, even on favorable media and under pure-culture conditions, by the use of these partial stimuli. Nevertheless, the percentage of failures has usually been small. By means of the stimulus given by magnesium phosphite it has also been possible to get growth from the spores in test-tube cultures with gray filter paper as the solid substratum and various plant decoctions and culture solutions as the nutrients. Details of these results, however, may be omitted.

In many cases it has been possible to obtain growth from the spores by the use of the stimulating salts which have been mentioned in connection with the germination studies. Where it is desired to make experiments along this line the writer has found it more practicable to use spores from a mushroom as young as possible. If one takes a mushroom just at the time that the veil is breaking, inoculations may be readily made from the spores and few contaminations will result. In this case, by means of a sterile needle, or scalpel, a few spores may be removed from the spore-bearing, or gill, surface and these may be transferred to the tubes in the same way as were bits of the fresh tissue. It is also possible to secure a spore print from a mushroom the gill surface of which has not been exposed to germs of the atmosphere. In the latter case it is desirable to remove stem and partial veil, peel off the incurved edges of the cap which have been in contact with the soil, and place the cap, gill surface downward, in a sterilized dish or on sterile paper. If this is then kept free from dust, a spore print may be obtained, which should not be contaminated by foreign germs. This print may then be used in making a large number of spore cultures.

Experiments were also made in which pots of unsterile composts and manures were inoculated, on the one hand, with spores, and, on

the other hand, for control purposes, with spawn from pure cultures. The duration of the experiments was two months. Some of these pots were watered with a mineral nutrient solution including as one constituent magnesium phosphite, designated *X*, others with the same solution to which was also added a small quantity of dried blood, designated *Y*, and the remainder with pure water. The results are tabulated as follows:

TABLE III.—*Extent of growth of spores and spawn in pots.*

	Cattle manure, old.	Fresh stable manure and sand.	Stable manure.	Old stable manure and sand.	Old stable manure.	Fertilizer.
Spores	*a*—Good	None	Slight	None	None	*Y.*
	b—None	do	do	do	do	*Y.*
Spores	*a*—Good	Very good	do	do	do	*X.*
	b— Do.	do	do	do	do	*X.*
Spawn	*a*—Slight	Slight	None	do	do	*Y.*
	b— Do.	do	Slight	do	do	*Y.*
Spawn	*a*—None	None	Good	do	do	*X.*
	b— Do.	do	Slight	do	do	*X.*
Spawn	*a*—None	Slight	do	do	do	None.
	b— Do.	do	None	do	do	Do.

TISSUE CULTURES.

The suggestion which had presented itself of using bits of living tissue from a sporophore instead of spores seemed also, from general observations, to be of sufficient importance to warrant a thorough trial. During moist weather, or in a moist cellar where mushrooms are being grown, one will frequently find that an injury in a young mushroom is rapidly healed by a growth of hyphæ from the edges of the injured area. The same thing had been noted in the open in the case of puffballs. In many instances, moreover, pure cultures of fungi in other groups have been obtained by the use of small bits of a sclerotial mass of tissue. Accordingly, a young sporophore of *Agaricus campestris* was obtained, and after breaking it open longitudinally a number of pieces of tissue from within were carefully removed with a sterile scalpel to a sterile Petri dish. A number of cultures were then made by this tissue-culture method on a variety of nutrient media, such as bean pods, manure, leaf mold, etc. From this and from numerous other similar tests it was ascertained that when the mushrooms, from which the nocules of tissue are taken, are young and healthy, there is seldom an instance in which growth does not result. It was easily shown that failure to grow was generally due to the advanced age of the mushroom used, to an unfavorable medium, or to bacterial contamination.

The first successful pure cultures were made by this method during the early spring of 1902 from mushrooms grown indoors. During

the following summer, or as other fleshy fungi appeared in the open, cultures were made from other forms in order to determine the general applicability of the method. The experiments were successful in most cases, although it was found almost impossible to obtain certain species of fungi in a condition young enough to be free from bacterial infestation. In general, the method seemed to commend itself strongly as a means of procuring pure cultures of desirable edible species, particularly of those species the spores of which could not be obtained pure or which could not be readily germinated.

During the two subsequent seasons this method has been employed with a great variety of fungi representing many natural orders. No systematic endeavor has been made to determine the limitations of the tissue-culture method as applied to Basidiomycetes, but, incidental to the general studies, cultures have been made from forms differing very widely, not only in relationship but also in texture and in habitat.

In all there is a record of 69 species having been tested upon one or another medium. In a few cases the cultures have invariably been contaminated, and it is to be supposed, perhaps, that the plants were collected in a condition too old for the purpose in hand. In only about ten forms has it seemed that there is no evident reason for the failure to develop mycelium. Of the remainder fully 40 have grown promptly on the media employed. The table following indicates the names of the species employed and the results obtained. It must be said, however, that cultures of a number of species were made of which no record was kept; among these, also, some grew and some failed.

TABLE IV.—*Results obtained from different species.*

Fungus.	Number of cultures.[a]	Substratum.	Result.
Agaricus arvensis	Few.	Beans, manure, leaves, etc	Rapid growth.
Agaricus augustus	1	Beans	Contaminated.
Agaricus campestris (various varieties).	∞	Beans, manure, leaves, etc	Rapid growth.
Agaricus fabaceus	∞	do	Do.
Agaricus fabaceus var	∞	do	Do.
Agaricus placomyces	1	Beans	Some growth.
Agaricus villaticus	Few.	Manure, leaves, etc	Rapid growth.
Amanita frostiana	1	Leaves	Contaminated.
Amanita muscaria	2	Beans	Do.
Amanita verna	2	do	Do.
Amanitopsis vaginata	2	do	Do.
Armillaria mellea	∞	Beans, leaves, dead wood, etc	Rapid growth.
Boletinus porosus	2	Beans	Slow growth.
Boletus felleus	2	do	No growth.
Boletus miniato-violaceus	1	do	Do.
Boletus peckii	2	do	Contaminated.
Bovistella ohiensis	Few.	Beans, leaves, etc	Rapid growth.
Calvatia craniiformis	Few.	do	Do.
Calvatia cyathiforme	∞	Beans, leaves, soil, etc	Do.
Calvatia rubro-flava	Few.	Beans, leaves, etc	Do.
Cantharellus cibarius	1	Beans	No growth.
Clavaria formosa	1	do	Do.

[a] ∞ indicates an indefinite number.

TABLE IV.—*Results obtained from different species*—Continued.

Fungus.	Number of cultures.	Substratum.	Result.
Clitocybe illudens	2	Beans	Some growth.
Clitocybe sp.?	2	do	Rapid growth.
Clitopilus prunulus	Few.	Beans, manure, etc	Some grew well.
Collybia platyphylla	1	Beans	No growth.
Collybia radicata	Few.	do	Good growth.
Collybia velutipes	1	do	Do.
Coprinus atramentarius	∞	Beans, leaves, manure, etc	Rapid growth.
Coprinus comatus	∞	Beans, manure, leaves, etc	Do.
Coprinus fimetarius	Few.	Beans, leaves	Do.
Coprinus micaceus	∞	Beans, leaves, manure, etc	Do.
Cortinarius armillatus	1	Beans	Contaminated.
Cortinarius castaneus	1	do	Do.
Cortinarius sp.?	Few.	Beans, leaves, manure	Good growth.
Daedalia quercina	Few.	Beans, leaves, manure, etc	Rapid growth.
Hydnum caput medusae	1	Beans	Good growth.
Hydnum coralloides	2	do	Do.
Hydnum erinaceum	2	do	Do.
Lactarius corrugis (?)	Few.	Beans and leaves	Slight growth, one.
Lactarius piperatus	∞	do	No growth.
Lactarius volemus	1	Acid beans	Some growth.
Do	∞	Beans	No growth.
Lepiota americana	1	do	Do.
Lepiota morgani	2	do	Some growth.
Lepiota procera	∞	Beans, leaves, etc	Rapid growth.
Lepiota rhacodes	Few.	do	Do.
Lycoperdon gemmatum	2	Beans	Good growth.
Lycoperdon wrightii	1	Sod	Do.
Morchella esculenta	2	Beans and leaves	Do.
Pluteus cervinus	Few.	do	Some growth.
Pleurotus ostreatus	∞	Beans, leaves, manure, etc	Rapid growth.
Pleurotus ulmarius	1	Beans	Do.
Pholiota adiposa	1	Beans and leaves	No growth.
Polyporus betulinus	1	Beans	Slow growth.
Polyporus intybaceus	1	do	Do.
Polyporus sulphureus	2	Beans and leaves	Rapid growth.
Polystictus cinnabarinus	2	do	Good growth.
Russula adusta	1	Beans	No growth.
Russula emetica	∞	Beans, etc	Often contaminated but some grew.
Russula sp	Few.	Beans	No growth.
Russula sordida	1	do	Do.
Russula virescens	Few.	do	Do.
Secotium acuminatum	2	do	Slow growth.
Strobilomyces strobilaceus	1	do	No growth.
Stropharia sp	1	do	Contaminated.
Tremella mycetophila	1	do	No growth.
Tricholoma personatum	1	Beans and manure	Good growth.
Tricholoma russula	2	Beans and leaves	Do.

It is not to be understood that the failures recorded in the foregoing table indicate that these species will not grow. The evidence is that they did not grow upon the media used, and it is very probable that most of these could be propagated in culture by this method if a systematic attempt were made to determine what substrata are desirable. The writer believes that this statement holds true particularly in the case of certain species of Boletus. No attempt was made to cultivate Boleti in any other way than upon bean pods. A few mycelial threads were developed in such cases, but these failed to grow upon the bean, apparently dying before even the nutrients in the fragment of tissue were exhausted.

It is interesting to note that many of the fungi which have given good growth have not hitherto been grown in pure culture. Accord-

[a] Costantin et Matruchot. Sur la production du mycelium des champignon supérieurs. Extrait Compt. Rend. d. Séances de la Soc. de Biologie. January,

ing to Costantin and Matruchot,[a] Van Tieghem (1876) produced the mycelium of Coprinus in pure culture. Later, Brefeld[a] accomplished the same result with many species of Coprinus, and also with *Armillaria mellea*. Costantin has also published a number of brief papers, or announcements, of successful cultures upon artificial media of the mycelium of several fleshy fungi. Besides *Agaricus campestris*, he has grown the mycelium of *Amanita rubescens*, *Armillaria mellea*, *Collybia velutipes*, *Lepiota procera*, *Marasmius oreades*, *Tricholoma nudum*, *Pleurotus ostreatus*, *Pholiota aegerita*, *Coprinus comatus*, *Polyporus tuberaster*, *P. frondosus*, *Hydnum coralloides*, *Morchella esculenta*, and perhaps a few others. He has also grown to maturity sporophores of *Agaricus campestris*, *Coprinus comatus*, and *Tricholoma nudum*. Unfortunately, Costantin seldom indicates the substratum upon which his cultures were made. Falck[b] reports having produced in culture the sporophores of *Collybia velutipes*, *Phlebia merismoides*, *Hypholoma fasciculare*, *Chalymotta campanulata*, and *Coprinus ephemerus* in his studies upon the connection of oidial stages with perfect forms of the Basidiomycetes. In the work of the writer so far no special attempt has been made to obtain the sporophores of the fungi cultivated except in the case of *Agaricus campestris*. Nevertheless, the following species have fruited in pure culture upon the media indicated:

	Medium.
Agaricus campestris	Manure.
Agaricus fabaceus	Manure.
Agaricus amygdalinus	Manure.
Armillaria mellea	Beans.
Bovistella ohiensis	Soil.
Calvatia cyathiforme	Soil.
Calvatia rubro-flava	Soil.
Cortinarius sp	Soil.
Coprinus comatus	Leaves.
Coprinus fimetarius	Leaves.
Coprinus solstitialis (?)	Leaves, etc.
Daedalia quercina	Leaves, etc.
Hydnum coralloides	Beans.
Lycoperdon wrightii	Soil.
Pleurotus ostreatus	Beans and manure.
Pleurotus ulmarius	Manure.

In some instances the sporophores have been minute, owing to the small quantity of the culture medium.

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[a] Brefeld, O. Unters. aus d. Gesammtgebiete d. Mykologie, 8, 9, 10.

[b] Falck, R. Die Cultur der Oidien und die Rückführung in die höhere Fruchtform bei den Basidiomyceten. Cohn's Beiträge zur Biologie der Pflanzen, 8: 307–346 (Pls. 12–17).

From the standpoint of obtaining pure cultures, the tissue-culture method is capable of very general application. Three considerations render it particularly important, as follows: (1) When a suitable culture medium is at hand, a pure culture may be obtained almost invariably from a young, healthy plant. (2) Cultures may be made from fungi the spores of which have never been brought to germination. (3) Pure cultures are made by direct inoculation; that is, dilution cultures are rendered wholly superfluous. In the case of *Agaricus campestris* and other Basidiomycetes, in which the gill-bearing surface is protected until the spores are produced, it is possible, with the precautions previously mentioned, to obtain the spores pure, or practically pure, and at the same time in considerable quantity. This is not possible with the great majority of fleshy fungi, which are truly gymnocarpous. Again, members of the genus Coprinus are deliquescent, and here it is impracticable to secure spores by the spore-print method. In the Lycoperdaceæ and other Gasteromycetes it has been found that bacteria are frequently present in the tissues by the time the spores are formed, and, even if the spores could be germinated, direct cultures would perhaps be seldom possible. By the tissue method it is only necessary that the plant shall be so young that the cells of the tissue are capable of growth and that there are no foreign organisms present in the tissue. In this connection it may be stated that in the Phallineæ, Hymenogastrineæ, and Lycoperdineæ no representative has been germinated, while in the Plectobasidineæ germination is known only in the case of *Sphaerobolus stellatus and Pisolithus crassipes.*

When the natural conditions of germination shall have been more definitely ascertained, direct spore-culture methods should in practice, perhaps, replace the pure tissue-culture methods in making virgin spawn. This would render unnecessary a tedious portion of the work, and the process of spawn making would be thereby made less expensive.

A discussion of the respective practical merits of the spore and tissue methods would not be complete without reference to the comparative vigor, or productive power, of the resulting mycelium. In the growth of the mycelium no difference could be detected. The writer has also grown mushrooms from spawn produced by both of these methods; but the results do not indicate that there is any advantage for the one over the other. It is believed, therefore, that the processes of basidial and spore formation are in this regard relatively unessential, or at least do not intensify whatever invigoration may, in general, result from mere sporophore production. It is to be expected, perhaps, that any and all cells of the sporophore may be invigorated by whatever is to be gained by the assemblage, or concentration, in the differen-

tiated sporophore, of food products collected by a ramifying mycelium. According to the studies of Harper,[a] Maire,[b] and others, there is no sexual fusion in the case of the Basidiomycetes which have been studied. Two nuclei are present in the cells of the sporophore, but these are associated conjugate nuclei, and the fusion of these in the basidium is generally considered in no sense an act of fertilization, but rather a form of nuclear reduction. Maire states that the cells of the mycelium obtained by the germination of the basidiospore are uninucleate. It has not yet been ascertained when or how the binucleate condition arises.

NUTRITION.

Although *Agaricus campestris* has been cultivated for so long a time, it does not seem that it has previously been subjected to careful experimentation from the point of view of nutrition. The belief generally prevalent is that the most essential factor in the nutrition of the mushroom is the "ammonia" of the manure or compost. Again, it is claimed that organic waste products, such as those indicated, must undergo a process of fermentation, or "preparation," in order to furnish the necessary nutrients for the growing mycelium. This idea, as will be seen later, is merely based upon casual observations "in nature," and it is found wholly erroneous when tested for its fundamental worth by the elimination of other factors of the compost environment.

Growth on manure and other complex media.—Early in this investigation it was ascertained that the mycelium of *Agaricus campestris* in pure cultures would grow luxuriantly on fresh stable manure, and as a rule upon the same product in any stage of fermentation or decomposition. In some instances, undoubtedly, fresh manure may contain injurious compounds; somewhat oftener the same is true for the fermented product. In some instances it is desirable to dry or thoroughly air the fresh manure before use. Fresh manure from grass-fed animals is not to be recommended. The mycelium also grows luxuriantly on bean stems or pods, on half-rotted leaves of deciduous trees, on rich soil, on well-rotted sawdust, and on a variety of other substances. It does not grow readily upon peaty products.

Some of the more promising edible species were cultivated in various media in order to obtain an idea of the comparative value of these media in furnishing a nutrient to particular forms. It is not possible, of course, to base definite conclusions upon results obtained

[a] Harper, R. A. Binucleate cells in certain Hymenomycetes. Bot. Gaz., 33: 1–25. 1902.

[b] Maire, R. Recherches cytologiques et taxonomiques sur les Basidiomycetes. Bul. Soc. Myc. de France, 18: 1–209. 1902.

from pure cultures, since the presence of particular foreign organisms in the substratum under natural conditions is perhaps quite as important a consideration as that of the specific nutrient value of the substratum. The following results are, however, suggestive:

1. Agaricus campestris.
   Leaves—good growth throughout.
   Soil—fair growth, with tendency to become threaded early.
   Manure—good growth throughout.
   Beans—good growth throughout.
   Sugar beet—fair growth, spreading very slowly.
   Potato—slight growth, spreading very slowly.
   Corn meal—slight growth, spreading slowly, soon becoming brown.
2. Agaricus fabaceus.
   Leaves—very good growth, rapidly filling tube.
   Soil—good growth, but slower than the above.
   Manure—good growth, but slower than the above.
   Beans—very dense growth, soon filling whole tube.
   Sugar beet—good growth; somewhat less rapid and abundant than the above.
3. Agaricus villaticus.
   Practically the same as *Agaricus campestris.*
4. Agaricus fabaceus var.
   Practically the same as *Agaricus fabaceus.*
5. Bovistella obiensis.
   Leaves—good growth throughout.
   Soil—growth throughout, but sparse and threadlike.
   Manure—good growth throughout.
   Beans—good growth; appressed.
   Sugar beet—very slight growth.
6. Calvatia cyathiforme.
   Leaves—very good growth throughout.
   Soil—good growth; quite as rapid as above.
   Manure—practically no growth.
   Beans—good growth, but spreads very slowly.
   Sugar beet—slight growth.
7. Calvatia craniiformis.
   Practically the same as above.
8. Calvatia rubro-flava.
   Practically the same as in the other species of this genus, but spreads somewhat more slowly on soil.
9. Coprinus atramentarius.
   Leaves—very good growth throughout.
   Soil—slight growth.
   Manure—fair growth, but very slow.
   Beans—very good growth.
10. Coprinus comatus.
   Leaves—very good growth throughout; rapid.
   Soil—good growth.
   Manure—very good growth throughout; rapid.
   Beans—very good growth throughout; rapid.
   Sugar beet—very slow growth.

11. Lepiota rhacodes.
    Leaves—very good growth.
    Soil—slight growth.
    Manure—slight growth.
    Beans—very good growth throughout.
    Sugar beet—very good growth throughout.
12. Morchella esculenta.
    Leaves—very good growth; mycelium never dense.
    Soil—very little growth.
    Manure—very slight growth.
    Beans—very good growth.
    Sugar beet—good growth, but slower than above.
13. Pleurotus ostreatus.
    Leaves—very good growth; rapid.
    Soil—fair growth.
    Manure—good growth.
    Beans—very good growth; rapid.
    Sugar beet—slight growth; very slow.
14. Pleurotus ulmarius.
    Practically the same as Pleurotus ostreatus.
15. Polyporus sulphureus.
    Leaves—fair growth; abundant, filling tube.
    Soil—fair growth.
    Manure—fair growth, but very slow.
    Beans—very good growth, rapidly filling tube.
    Sugar beet—fair growth; much lighter mycelium than the above, with prompt oidial development.
16. Tricholoma personatum.
    Leaves—very good growth throughout.
    Soil—very good growth throughout.
    Manure—growth slow, but eventually good.
    Beans—good growth throughout.

Plates II, III, and IV show some of the more important of these species.

Taking into consideration the variable quality of the stable manure which may be obtained at all seasons, the value of half-rotted deciduous leaves as a substratum for Basidiomycetes is worthy of special emphasis. The writer has found such material more readily sterilized than manure, and usually more prompt than the latter to give growth.

In order to test in pure cultures the probable effect of fertilizers as indicated by any marked increase in the rapidity of growth of the mycelium, experiments were made by adding a small quantity of ordinary nutrient salts to test tubes containing manure. A chlorid and a nitrate of the following salts were employed, viz, ammonium, calcium, magnesium, and potassium. In addition, dibasic potassium phosphate and also sodium chlorid, as well as control cultures, were used. Three tubes were employed with each of the compounds mentioned. There was no marked difference in the amount or rapidity of the growth noted, as found by comparing the averages of growth.

It seemed possible, however, that some slight advantage resulted from the calcium compounds, but there was no pronounced benefit in any tube. Further reference is made to the use of nutrient salts in mushroom growing in another chapter.

Growth on chemically known media.—In an attempt to determine somewhat more accurately the value of different compounds as nutrients, particularly carbohydrate and nitrogenous substances, several series of extensive tests have been made with *Agaricus campestris*, and also with *Agaricus fabaceus* and *Coprinus comatus*. These fungi do not grow readily in liquid media, and it has been difficult to obtain a wholly reliable and satisfactory substratum, one which would itself be practically pure, or well known, chemically, and at the same time effective for its purpose. After unsatisfactory attempts with various gelatinous solid media, with charcoal, etc., it was decided that the commercial gray filter paper had more to recommend it than any other substance suggested. Accordingly, all experiments were made in Erlenmeyer flasks of 150 c. c. capacity, and in each flask was placed about 6 grams of this paper wadded into pellets. The latter was moistened in each case with the nutrient solution used. The flasks were subsequently sterilized in the autoclave and then inoculated with a very minute fragment of straw with the fresh mycelium from a pure culture on manure.

Tabulation of special results.—In the following tables are given the results of two out of several series of experiments, which have been conducted in order to throw some light on the point just discussed. These tables include, also, many cultures on media of unknown composition.

TABLE V.—*Results of growth on media—First series of experiments.*

No.	Medium.	Extent of growth.
1a	Dt. H_2O	Very slight.
1b		Do.
2a	Solution A	Do.
2b		Do.
3a	Solution A and cane sugar, 1½ per cent	Do.
3b		Do.
4a	Cane sugar, 1½ per cent	Do.
4b		Do.
5a	Solution A and lactose, 1½ per cent	Do.
5b		Do.
6a	Lactose, 1½ per cent	Do.
6b		Do.
7a	Solution A and glycerin, 1½ per cent	Do.
7b		Do.
8a	Glycerin, 1½ per cent	Do.
8b		Do.
9a	Solution A and starch paste, ½ per cent	Fair growth
9b		Do.
10a	Starch paste, ½ per cent	Do.
10b		Do.
11a	Solution A and starch, ½ per cent, and diastase, trace	Contaminated, discarded.
11b		Fair.
12a	Starch, ½ per cent, and diastase, trace	Good.
12b		Do.
13a	Solution A and dextrose, 1½ per cent	Very slight.
13b		Good.

TABLE V.—*Results of growth on media—First series of experiments*—Continued.

No.	Medium.	Extent of growth.
14a	Dextrose, 1½ per cent	Slight.
14b		Do.
15a	Solution A and mannite, 1½ per cent	Very slight.
15b		
16a	Mannite, 1½ per cent	Lost.
16b		
17a	Solution A and maltose, 1½ per cent	Contaminated with Aspergillus. Fair growth, yellowish in color.
17b		
18a	Maltose, 1½ per cent	Fair.
18b		Do.
19a	Solution A and potassium tartrate, ½ per cent	Slight.
19b		Do.
20a	Potassium tartrate, ½ per cent	Do.
20b		Do.
21a	Solution A and magnesium tartrate, ½ per cent	Do.
21b		Do.
22a	Magnesium tartrate, ½ per cent	Do.
22b		Do.
23a	Solution A and ammonium tartrate, ½ per cent	Do.
23b		Do.
24a	Ammonium tartrate, ½ per cent	Do.
24b		Do.
25a	Solution A and potassium lactate, ½ per cent	Do.
25b		Do.
26a	Potassium lactate, ½ per cent	Do.
26b		Slight to fair.
27a	Solution A and magnesium lactate, ½ per cent	Slight.
27b		Do.
28a	Magnesium lactate, ½ per cent	Do.
28b		Do.
29a	Solution A and ammonium lactate, ½ per cent	Fair to good.
29b		Do.
30a	Ammonium lactate, ½ per cent	Slight.
30b		Do.
31a	Solution A and calcium hippurate, ½ per cent	Very good.
31b		Do.
32a	Calcium hippurate, ½ per cent	Slight.
32b		Do.
33a	Solution A and asparagin, ½ per cent	Do.
33b		Do.
34a	Asparagin, ½ per cent	Do.
34b		Do.
35a	Solution A and peptone, ½ per cent	Good.
35b		Do.
36a	Peptone, ½ per cent	Very slight.
36b		Do.
37a	Solution A and casein, ½ per cent	Very good.
37b		Do.
38a	Casein, ½ per cent	Do.
38b		Do.
39a	Solution A and pepsin, ½ per cent	Slight to fair.
39b		Do.
40a	Pepsin, ½ per cent	Do.
40b		Do.
41a	Solution B	Do.
41b		Do.
42a	Solution B and asparagin, ½ per cent	Slight.
42b		Do.
43a	Solution B and peptone, ½ per cent	Very slight.
43b		Do.
44a	Solution B and casein, ½ per cent	Very good.
44b		Do.
45a	Solution B and pepsin, ½ per cent	Culture lost.
45b		Do.
46a	Bouillon	Slight to fair.
46b		Do.
47a	Bean decoction	Very good.
47b		Do.
48a	Beet decoction	Good to very good.
48b		Do.
49a	Manure decoction	Very good.
49b		Do.
50a	Manure	Do.
50b		Do.
51a	Wheat straw	Lost.
52a	Solution A and wheat straw	Do.
52b		Do.
53a	Solution B and wheat straw	Do.
53b		Do.
54a	Solution B and NH_4NO_3 and cane sugar	Slight to fair.
54b		Do.
55a	Solution B and cane sugar and $Ca(NO_3)_2$, ½ per cent	Very slight.
55b		Do.

TABLE V.—*Results of growth on media—First series of experiments*—Continued.

No.	Medium.	Extent of growth.
56a	Solution B and sugar and $Mg(NO_3)_2$, ½ per cent	Very slight.
56b		Do.
57a	Solution B and sugar and NH_4Cl, ½ per cent	Do.
57b		Do.
58a	Solution B and NH_4NO_3, ½ per cent	Do.
58b		Do.
59a	Solution B and $Ca(NO_3)_2$, ½ per cent	Do.
59b		Do.
60a	Solution B and $Mg(NO_3)_2$, ½ per cent	Do.
60b		Do.
61a	Solution B and NH_4Cl, ½ per cent	Slight to fair
61b		Do.
62a	Mushroom decoction	Do.
62b		Do.

TABLE VI.—*Results of growth on media—Second series of experiments.*

No.	Medium.	Extent of growth.
1a	Fresh horse manure (grass-fed animals)	None.
1b		Slight.
2a	Fresh horse manure, thoroughly washed, residue only used	Contaminated.
2b		Good.
3a	Filtrate, or liquid resulting from washing No. 2	Good.
3b		Contaminated.
4a	Decoction of fresh horse manure, as in No. 1	Fair.
4b		Do.
5a	Fermented horse manure, thoroughly washed	Very good.
5b		Do.
6a	Filtrate or washing from No. 5	Slight.
6b		Do.
7a	Rotted stable manure	Good.
7b		Contaminated.
8a	Decoction of green timothy hay	Good.
8b		Do.
9a	Residue from decoction in No. 8	None.
9b		Do.
10a	Strong bean juice	Slight.
10b		Contaminated.
11a	Weak bean juice	Good.
11b		Do.
12a	Strong decoction of mushrooms	Slight.
12b		Do.
13a	One-half strength decoction of mushrooms	Slight.
13b		Contaminated.
14a	Weak decoction of mushrooms	Slight.
14b		Do.
15a	Oat straw	Contaminated.
15b		Slight.
16a	Wheat straw	Good.
16b		Do.
17a	Corn meal	Fair.
17b		Do.
18a	½ gram cane sugar in 25 c. c. solution A	Slight.
18b		Confined to nocules.
19a	½ gram milk sugar in 25 c. c. solution A	Do.
19b		Slight throughout.
20a	½ gram galactose in 25 c. c. solution A	Do.
20b		Slight, but contaminated.
21a	½ gram cornstarch in 25 c. c. solution A	Slight at top.
21b		Lost.
22a	½ strength albumen (egg)	Confined to nocules.
23a	½ gram glucose in 25 c. c. solution A	Slight at top.
23b		Do.
24a	½ gram dextrose in 25 c. c. solution A	Fair throughout.
24b		Do.
25a	½ gram mannite in 25 c. c. solution A	Fair.
25b		Contaminated.
26a	½ gram glycogen in 25 c. c. solution A	Slight; contaminated.
26b		Fair.
27a	½ gram maltose in 25 c. c. solution A	Slight at top.
27b		Do.
28a	½ gram levulose in 25 c. c. solution A	Slight.
28b		Slight at top.
29a	½ gram glycerin in 25 c. c. solution A	Confined to nocules.
29b		

TABLE VI.—*Results of growth on media—Second series of experiments*—Cont'd.

No.	Medium.	Extent of growth.
30a	½ gram potassium tartrate in 25 c. c. solution A	Very slight: contaminated.
30b		Do.
31a	½ gram magnesium tartrate in 25 c. c. solution A	Confined to nocules.
31b		Do.
32a	½ gram potassium lactate in 25 c. c. solution A	Do.
32b		Do.
33a	½ gram potassium lactophosphate in 25 c. c. solution A	Slight at top.
33b		Do.
34a	½ gram magnesium citrate in 25 c. c. solution A	Do.
34b		Do.
35a	½ gram magnesium malate in 25 c. c. solution A	Do.
35b		Do.
36a	½ gram calcium hippurate in 25 c. c. solution A	Good top.
36b		Do.
37a	½ gram asparagin in solution A	Slight.
37b		Do.
38a	½ gram urea in solution A	Confined to nocules.
38b		Do.
39a	½ gram peptone in solution A	Fair at top.
39b		Do.
40a	½ gram casein in solution A	Fair throughout.
40b		Do.
41a	½ gram benzoic acid in solution A	None.
41b		Do.
42a	½ gram benzoic acid in solution A	Do.
42b		Do.
43a	Solution A	Confined to nocules.
43b		Do.
44a	Solution B	Do.
44b		Do.
45a	Distilled HO	Do.
45b		Do.
46a	Decoction from productive old bed	Fair throughout.
46b		Do.
47a	Oak sawdust, only slightly rotted	Confined to nocules.
47b		Do.
48a	Gluten meal and water	Good throughout.
48b		Do.
49a	Cotton-seed meal and water	Contaminated.
49b		Do.
50a	Cotton-seed meal	Slight at top.
50b		Contaminated.
51a	½ gram asparagin in solution B	Slight at top.
51b		Do.
52a	½ gram asparagin in solution B	Fair.
52b		Do.
53a	½ gram urea in solution B	None.
53b		Do.
54a	½ gram urea in solution B	Slight at top.
54b		Do.
55a	½ gram urea in solution B	Slight throughout.
55b		Do.
56a	½ gram peptone in 25 c. c. solution B	Slight at top.
56b		Do.
57a	½ gram peptone in 25 c. c. solution B	Do.
57b		Do.
58a	½ gram peptone in 25 c. c. solution B	Fair at top.
58b		Do.
59a	½ gram peptone and $\frac{1}{10}$ gram $NaNO_3$ in solution B	Fair throughout.
59b		Slight.
60a	½ gram casein in 25 c. c. solution B	Very slight.
60b		Do.
61a	½ gram casein in 25 c. c. solution B	Fair at top.
61b		Slight at top.
62a	$\frac{1}{10}$ gram casein in 25 c. c. solution B	Fair throughout.
62b		Do.
63a	½ strength albumen (egg)	Slight at top.
63b		Do.
64a	Oil meal and water	Good throughout.
64b		Do.
65a	White pine shavings	Very small area, but copious.
65b		Do.
66a	White pine shavings with bean decoction	Do.
66b		Do.
67a	Asbestos with bean decoction	Confined to nocules.
67b		Do.
68a	Old flake spawn	Very good.
68b		Do.

It is not possible here to enter into a detailed discussion of the results, but attention is directed to the fact that under ordinary conditions *Agaricus campestris* does not give a copious growth when nitrogen is furnished from an inorganic salt and carbon in the form of the well-known sugars. Calcium hippurate in a solution of the necessary salts has almost invariably given better growth than other organic salts and carbohydrates. In general, casein has been a better source of carbon, or of carbon and nitrogen, than other proteids.

When the manure is of good quality it furnishes, in pure cultures, a source of necessary nutrients, whether fresh or fermented, whether as a decoction or an infusion (a cold aqueous extract).

Acid and alkaline media.—Manure which has undergone fermentation for a few weeks is usually slightly acid in reaction. Under certain conditions of fermentation the acidity is increased, and this is probably an important factor in making the manure from animals fed with green foods less valuable for mushroom work. Some acid tests were made of beds which had failed to yield satisfactory results, and in many instances it was found that the acid content was much above the normal. A small series of experiments was therefore instituted to determine the relative amount of acidity or of alkalinity most favorable for the growth of the spawn under pure-culture conditions. In this test there were also included several other edible fungi, the results of all of which are included in the table below. These experiments were made in large test tubes, and in such a test it was impracticable to determine absolute acidity or alkalinity, and from the results only a rough qualitative comparison could be anticipated. Potassium hydrate and lactic acid were used as reagents. The duration of the experiments was one month, and duplicate cultures were used in every instance.

Although the results are not wholly uniform, it may be inferred that in the case of *Agaricus campestris* a marked acidity of the medium would be unfortunate; *Calvatia cyathiforme*, on the other hand, seems to have grown somewhat better, in general, in the more acid media; *Coprinus comatus* grows under a wider range of conditions; and *Coprinus atramentarius*, in this instance, thrives in an alkaline medium. Further tests on a quantitative basis are required before definite conclusions may be drawn. This matter will also receive further attention when facilities are at hand for undertaking to better advantage than has yet been possible the practical growing of the other species, besides *Agaricus campestris*, included in this test.

TABLE VII.—*Results of tests of acidity and alkalinity.*

Medium.	Nature of stable compost.	Extent of growth.			
		Agaricus campestris.	Calvatia cyathiforme.	Coprinus comatus.	Coprinus atramentarius.
4 drops KHO	Fresh	Very slight	Very slight	Slight	1 good, 1 very slight.
	Rotted	Slight	do	Very slight	Contaminated.
2 drops KHO	Fresh	1 good, 1 fair.	1 none, 1 slight.	1 very good, 1 excellent.	Very slight.
	Rotted	Very good	None	Very good	Good
1 drop KHO	Fresh	Good	Very slight	Excellent	Very good.
	Rotted	Very good	None	do	Excellent.
Control	Fresh	1 very good, 1 fair.	1 good, 1 none	do	Very slight.
	Rotted	Very slight	Contaminated.	None	None.
1 drop acid	Fresh	1 contaminated, 1 very good.	1 slight, 1 good.	Excellent	Very slight.
	Rotted	Very slight	Very slight	do	Do.
2 drops acid	Fresh	do	do	do	Do.
	Rotted	do	Very good	None	Do.

TEMPERATURE AND MOISTURE.

The temperature factor is, next to that of good spawn, perhaps the most important in mushroom growing. It has been frequently stated that mushroom growing is not profitable when the temperature may not be maintained more or less continuously at from 50° to 60° F. It is very probable that the exact temperature which may be considered an optimum will vary somewhat in different sections of the country. It will be noted later in detail that the temperature factor acts not so directly upon the growth of the spawn or the production of mushrooms as indirectly to render some other conditions of the environment injurious. It is best to consider that in practice the optimum temperature for mushroom growing varies from 53° to 58° F.

When the matter of temperature was first under consideration, a series of pure cultures of *Agaricus campestris* was placed at different temperatures in the laboratory in order to determine the rapidity of growth. It was soon found that a temperature above 60° F. and, indeed, as high as from 80° to 85° F., was much more favorable to rapid growth than a lower temperature, provided, of course, that the higher temperature did not encourage a too rapid drying out of the culture. It was soon definitely ascertained that the conditions of pure-culture growth are essentially different from those attending the growth of mushroom spawn in the bed. This was perhaps best indicated by comparing spawn grown in pots at 85° F. under impure conditions with similar spawn grown at 50° F. At the former temperature, even though the conditions of moisture were properly maintained, there was little or no growth. Foreign fungi, molds, and bacteria, as well as insects, were, however, abundant. At the lower temperature there was little or no evident appearance of other fungi, molds, or insects;

yet the mushroom spawn grows slowly and continuously so long as other conditions are maintained. From numerous experiments of this nature it is apparent that the temperature relation is one which is governed by the competition to which the mushroom spawn is subject in the bed. This is, of course, wholly in accord with the results obtained from the study of the relative growth made by mushroom spawn in fresh and composted manures.

The statement previously made, therefore, that the optimum temperature may vary slightly in different localities is true on account of the fact that the mites, insects, and other animal pests of mushroom growing may vary considerably in different localities, or under different conditions, even though there may not be a great variation, perhaps, in the bacterial and fungus flora of the compost upon which the mushrooms are grown. Certain insects, for example, are more abundant in a moist climate, but if special precautions can be taken to eliminate all such pests, the growth problem is confined to the interrelation existing between the mushroom spawn and the microscopic flora of the compost. Mushrooms grown in the open will probably show greater variation with reference to the temperature factor than those grown in caves or cellars.

While a number of interesting problems would be presented by a study of the interrelation of the mushroom mycelium with that of other microscopic fungi present in the compost, these are matters of detail; and it has been wholly impossible thus far to give any attention to suggestions which have been furnished by the experimental data. It may be possible that other species of mushrooms are more independent of insects and other microscopic fungi, and such fungi may therefore be more suitable for cultivation at high temperatures than is *Agaricus campestris* or any of its close allies. A considerable effort is being made to obtain spawn of certain species of Agaricus, and also of other edible mushrooms which make their appearance during the warm weather. At this time, however, it is not possible to say what results of value may be anticipated from this line of work.

The direct effect of a temperature above the optimum upon the sporophores is manifest through lengthening of the stipes and rapid expansion of the caps, ordinarily accompanied by toughness and decreased size. In other words, the lower grade market product is produced at the higher temperature.

The moisture factor is also one of importance. It is undesirable that the place in which mushrooms are grown should be very damp, or dripping with water. Nevertheless, a fairly moist condition of the atmosphere should be maintained throughout the growing and productive period. There should be a gradual but slight evaporation from the surface of the beds, and sufficient ventilation to insure this

is believed to be essential. It is certain that in poorly ventilated caves mushrooms do not succeed. On the other hand, in a dry atmosphere, or exposed to drying winds, mushroom beds soon cease to bear, while such sporophores as are developing may have their caps cracked and torn.

Mushrooms are grown in cellars, caves, or specially constructed houses largely on account of the fact that temperature and moisture are then practically under control. The nature of the structure or cellar which is constructed for mushroom growing must be determined, therefore, not merely by its expense, but by the effectiveness of the structure in regulating the factors indicated under the particular climatic conditions.

It is not possible at this time to discuss cellar or house construction, and the accompanying illustration of mushroom houses (Plate VI, fig. 1) must suffice to give an idea of the types which are in use.

PREPARATION OF THE COMPOST.

It is not to be understood that there is one and only one method of preparing compost for mushroom growing. Nor is it always necessary that the compost shall be in one particular stage of fermentation or decay. In fact, every change of condition elsewhere may necessitate a similar change in the amount of fermentation which may be most desirable. At the outset it should be understood that it is not the "fermentation" which is absolutely essential.[a] The

[a] Répin, l. c. (See translation in The Garden (London), February 5, 1898, Special reprint, pp. 10–16.) Here it is stated that "manure is rendered capable of supplying nutriment suitable for mushrooms only by means of fermentation;" further, that "all the higher orders of mushrooms, the spores of which I have succeeded in causing to germinate, have a sterile spawn of a similar nature." Again, the conclusion is expressed somewhat indefinitely that manure is "rendered suitable" by means of chemical combustion, which is said to proceed rapidly only at a temperature above 178° F.; that it is not the soluble substances in the manure which are valuable, but rather the cellulose matter, together with the necessary salts.

In this connection it is of interest to note that the material constituting many of the beds in the experimental cellar at Columbia, Mo., were fermented at comparatively low temperatures. A complete temperature record was kept of 18 small compost piles in which special kinds of manure were prepared, and in only one instance was the temperature in any pile more than 140° F. In some cases 120° F. was the maximum attained.

Répin implies that mushrooms will not grow in manure until there has been effected "the destruction of all the soluble organic matters, which disappear through the agency of bacteria or are consumed in the process of oxidation." Very simple nutrition experiments clearly demonstrate that these conclusions are erroneous.

It may be stated, however, that peculiarities appear when the fresh manure contains certain compounds which render it injurious; for example, the mycelium does not grow readily in pure culture upon fresh manure from animals fed almost wholly on green forage. Such manure is improved by fermentation.

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" fermentation " is of itself a minor matter. In pure cultures, when sterile media are employed, mushroom spawn starts slowly, but finally grows best, in general, upon fresh (wholly unfermented manure. It grows least well, or, rather, less densely, so far as tested on very well fermented manure. This certainly indicates that it is not fermentation which is ordinarily advantageous. In practical mushroom growing, however, it is not possible to deal with pure cultures; and, therefore, other conditions of the environment must be correspondingly changed. The rapid oxidation action of bacteria and perhaps of independent ferments, upon manure causes a considerable rise of temperature. At the higher temperatures (which may be maintained as long as there are present rapidly oxidizable food products) bacterial action is vigorous, and is unquestionably injurious to mycelial development. Wholly aside from the rise of temperature accompanying their activities, bacteria are otherwise injurious. In fact, manure which is put to ferment in a small test tube shows little or no rise of temperature above that of the place in which it is incubated. Nevertheless, the mycelium of the mushroom will not grow under such conditions. Rapid bacterial action is therefore prejudicial. Under those conditions where bacterial action is not rapid, fresh manure might be used to advantage; in other words, if the beds are so constructed that the manure ferments very gradually, without either excessive bacterial action or rise of temperature, then spawning might be made in fresh manure.

The old belief that rotten manure does not have the necessary strength—that is, does not produce so vigorous a mushroom growth as that which has been less transformed by bacterial action—has been confirmed by practical experiments. This loss of effectiveness is probably due, in part, to a change in texture or to other physical changes. In well-rotted manure there is ample food material to support a very good growth of mycelium in pure cultures. This has been chemically proved by sterilizing such manure and growing mushroom spawn upon it in pure culture. Nevertheless, by comparing (in Table VIII) No. 12 with Nos. 13, 14, and 15, it will be seen that beds prepared with well-fermented manure and left for some time before spawning do not yield so well. It is believed that here the physical condition has much to do with the result.

The latter does not by any means invalidate the following practice, which has commended itself to some very successful growers: The manure is piled in very large compost heaps, where it is kept moist and is turned only once or twice. It ferments very slowly. Then it is carted into the cave, or mushroom house, long before it could be considered in proper condition to be spawned. The beds (usually flat when this is the procedure) are made immediately. These are fairly well moistened and compressed, then left to undergo a gradual

fermentation, which may require a month. When the manure shows a tendency to fall to the temperature of the room it is spawned. Meanwhile, it will doubtless be found that a heavy crop of some small species of Coprinus will have appeared. The presence of this fungus is not injurious, but rather it may be taken as an indication that the conditions are favorable.

Ordinarily the manure is obtained as fresh as possible. It should include the straw used in bedding the animals, and the quality of the straw will determine to some extent the value of the manure. The straw of cereals is far better than that of most other grasses. The more resistant straws seem greatly to improve the texture of the compost for mushroom purposes. Commercially it is a mistake to attempt to get the manure free from straw. If fresh manure is not obtainable, that which has been trampled by the animals is ordinarily rich, well preserved, and desirable. It ferments best in large piles, and these may be of considerable extent, about 3 or 4 feet deep throughout. If not uniformly moist the material should be sprinkled. At no time is a very heavy watering desirable. In from four days to a week or more the compost should be turned, or forked over, and a second turning will be required a week or ten days later. Water should be added only when necessary to maintain a moist (but not a wet) condition. With this amount of moisture, and with the piles deep enough to become fairly compact as a result of their own weight, there will be little danger of any injurious fermentation. During the normal fermentation the temperature may rise higher than 150° F. In from fifteen to twenty-one days or more, depending upon the conditions, the temperature will begin to fall, and the compost may be used in the construction of the beds. When used in the beds, it has ordinarily lost all objectionable odor, and the color of the straw has changed from yellow to brown. In figure 2 on Plate V is shown a shed in which the manure is composted during the summer.

As stated in Farmers' Bulletin No. 204:

> It is the custom with some growers to mix a small quantity of loam, about one-fourth, with the manure. This enables one to use the manure earlier; and, indeed, under such circumstances it may sometimes be used with but little or no composting. Nevertheless, the majority of growers have obtained greater success by the use of the manure alone, and this is also the writer's experience. Very well-rotted compost should not be used in mushroom growing if large and solid mushrooms are desired. When sawdust or shavings are employed for bedding the animals, the composting may require a somewhat longer period.

It has been the experience of some of the most successful growers that the use of shavings for bedding material in the stables does not injure the value of the product for mushroom work. The presence of a large amount of sawdust is, however, objectionable so far as the writer's experience goes. Compost containing much sawdust is

necessarily very "short," and therefore the physical condition is n the most favorable for *Agaricus campestris*.

In another chapter attention is called to the fact that the value c the manure depends to a considerable extent upon the feed given tl animals. It would not be wise to depend upon that obtained fro stables in which hay and green foods are used to too great an exten Moreover, it is not believed that compost made from the manure c cattle barns is in mushroom growing as desirable as stable manure.

In some cities the municipal ordinances require that the manu shall be promptly removed from the feeding stables or that it sha be disinfected. In the latter case crude carbolic acid, or even corr sive sublimate, may be used to secure this end. Manure thus disir fected is, of course, undesirable for mushroom work. For the sam reason the manure of veterinary hospitals is of questionable value.

It is not wholly improbable that some other waste products of th farm, field, and forest may be utilized in mushroom growing; never theless, no such product has yet been found which, under the condi tions of the experiment, has yielded sufficiently to make it of specia interest in growing *Agaricus campestris*. Among the products whicl have been tested, either alone or in conjunction with some commer cial fertilizer, are the following: Leaves of deciduous trees, needles o conifers, sawdust, cotton-seed hulls, cotton seed, corn stover, sorghum stover (or bagasse), rotten hay, sphagnum, and yeddo fiber. Th writer is convinced that greater profit may be anticipated, for th present, at least, if the culture of *Agaricus campestris* is confined t manure; and if other edible forms which grow in the woods are used in beds of leaves, etc., as indicated elsewhere in these pages, it is quite possible that such a fungus as *Coprinus comatus* may be grown successfully in this latter way. It may, however, be too much to hope that the morel may also be thus made amenable to culture, although leaf mold is in nature the favorite habitat of this fungus.

From the prompt and abundant growth of *Agaricus campestris* on half-rotted leaf mold in pure cultures, it was thought that mushrooms might be grown to advantage upon this product. The practical experiments made to test this point are distinctly discouraging, as shown by reference to No. 17, Table VIII; Nos. 3 and 4, Table IX, and No. 11, Table X.

For the most part manure may be composted in the open air. It may, however, be prepared with greater uniformity under cover. During midsummer, protection may be desirable on account of drying out, while in the winter it is more important in case of excessive cold. If it is necessary to compost manure during the winter, moreover, the piles should be of considerable depth.

INSTALLATION OF BEDS.

In making the beds, as well as in other phases of mushroom work, regard must be had for all environmental conditions. The type of bed should be determined by convenience, and the size, to a certain extent, by the temperature to which the beds may be exposed. The flat bed, frequently referred to as the English type, is more commonly employed in the indoor work in England and America. With this type merely the entire floor space may be utilized, as illustrated in the frontispiece, Plate I, or the beds may be arranged in tiers of shelves. In figure 1 on Plate V a view may be had of the supports for shelf beds in a large commercial house. In this house there is the greatest economy of space. The shelf system gives the greatest amount of bed space and is certainly most economical where the floor space is an important factor. Such beds do not require great depth, but merely sufficient to insure an ample development of spawn. They should be from 8 to 10 inches deep after being firmed or compressed.

The ridge-bed system is employed almost exclusively in the caves about Paris. This system is also in use in open-air culture. It may be used to advantage in low cellars, caves, or houses when labor is not too expensive. Ridge beds increase slightly the surface area and permit of easy passage from one part of the cave to another. The size of such beds in caves, or under other conditions where the temperature remains practically uniform, should be not more than 2 feet wide at the base and 15 inches high, tapering gradually to the top when compressed. Slanting beds are commonly employed next to the walls. Large beds are desirable under changeable open-air conditions.

The prevalent opinion among amateurs that the bed should always be deep enough to maintain a considerable heat is believed to be erroneous. Grown under more or less uniform conditions, mushrooms seem to require no bottom heat, and the bed should fall to the temperature of the room some time after spawning. Bottom heat, and hence large beds, are, however, desirable when sudden changes of weather would so reduce the temperature of the bed as to delay growth. Under similar conditions, as well as in dry air, mulching may be required.

As previously stated by the writer in Farmers' Bulletin No. 204 of the Department of Agriculture—

> In any case, the manure is made up in the form of the bed desired and should be firmed, or compressed, to some extent immediately, in order to prevent drying out and burning when the secondary fermentation takes place. At this time the manure should be neither wet nor dry, but merely moist. The only practical test of the proper moisture content of the manure which can be relied upon is when, upon compression, water can not readily be squeezed out of it.

SPAWNING AND CASING THE BEDS.

From what has been said concerning the temperature requirements, it will be evident that spawn should not be inserted in the beds until the temperature has fallen low enough to insure successful competition on the part of the mycelium with other organisms. In many articles on mushroom growing it has been suggested that beds may be spawned when the temperature has fallen to about 90° F. From experience and observation, the writer can only conclude that such a temperature is frequently fatal, and it is believed that the temperature of the beds should be permitted to fall to 70° F. before being spawned. In fact, the most successful results have been obtained at temperatures from 65° to 70° F. It was formerly believed that if the spawn were inserted at 90° F. this higher temperature incited the rather dormant mycelium to rapid and vigorous growth. It is clear, however, that the rapid development of new mycelium from the pieces of spawn brick inserted is not so important a factor as suitable conditions for continued growth. If the temperature falls rapidly from 90° F. after spawning, however, no injury may result. Nevertheless, it is to be considered an unfortunate condition.

The bricks of spawn may be broken into from ten to twelve pieces, from 1½ to 2 inches square. These pieces may be inserted about 1 inch beneath the surface of the manure. In flat beds they may be placed from 10 to 12 inches apart throughout the bed, and in ridge beds the pieces should be inserted on each side alternately, one near the top and the next near the bottom. It is well to insert the pieces vertically, as the mycelium does not then seem so readily to suffer damping off. After spawning, the beds should again be firmed, and they are then ready to be cased or loamed whenever this process may seem most desirable. At the time of spawning the beds should be in the best condition possible for the growth of the mycelium. Delay in growth at this time is one of the surest indications of a light yield. If the bed contains the proper amount of moisture, and if the walls and floors of the house or cellar are sprinkled occasionally, so as to maintain a moist condition of the atmosphere, it is possible to avoid wholly the use of water upon the beds immediately after spawning. In no case should a bed recently spawned be heavily watered. The surface may be sprinkled, if there is a tendency toward drying out. The same test for moisture content as has been outlined previously in these pages in the chapter on preparing the manure should be followed. The beds should become gradually somewhat drier, however, during the growth of the spawn.

The absolute water content for the bed at the time of spawning should be about 40 per cent, although this will vary considerably, according to the conditions, and especially with relation to the quantity of straw in the manure.

If the spawn grows rapidly at first and spreads throughout the bed, it will not be injured by a slight drying out, or by a temperature even as low as 32° F. On the other hand, a continuous high temperature for several days, or excessive watering, is sure to result in an irreparable injury. In several instances where the experimental beds of the writer have been made during the late autumn, and where a vigorous growth of spawn has been secured before the advent of the coldest weather, the beds have remained unproductive throughout the winter months, or so long as the temperature remained intermittently below 40° or 50° F. With warmer weather, these beds have come into bearing several months later, and where the temperature has then remained favorable for some time a good yield has been obtained. In this case, moreover, the bed will bear much longer at a temperature of 60° F., or above, than if the temperature has been constantly in the neighborhood of 60° F. throughout the growing season of the spawn. As a rule, beds thus filled with spawn and then subjected for a time to cold conditions yield at the outset much larger mushrooms than beds exposed to a more constant temperature, even if this constant temperature may be the optimum.

At any rate, the beds must be "cased" as soon as convenient after the spawn is inserted. As a rule, one should wait from one to two weeks in order to be sure that the spawn is growing. Casing consists in applying to the bed a layer of loam from 1 to 1½ inches deep. In France the casing soil consists usually of calcareous earth, sometimes mixed with loam. Ordinary loam of almost any quality will suffice. This should be secured in advance, and it is well to protect it from the weather, so that at a convenient time it may be worked over and, if necessary, screened, in order to free it from large pebbles or trash. When the loam is applied, it should, on ridge beds, be carefully firmed. When cased a bed should require watering for the most part merely to maintain a moist surface.

MUSHROOM GROWING.

EXPERIMENTS AT COLUMBIA, MO.

The practical experiments in mushroom growing which have been undertaken at Columbia, Mo., were designed, in the first place, to determine the exact effect of conditions upon the growth of mushrooms, and in the second place to test or immediately apply the results obtained or suggested by the laboratory work. The effects of temperature, moisture, etc., have already been discussed, and the conclusions drawn have been based upon the most careful observations of the experimental beds, as well as upon the evidence which has been obtained by a personal study of the conditions in commercial mushroom houses and caves both at home and abroad. It is needless to give in detail the record of all failures or of poor yields

invariably obtained when the conditions were unfavorable—that is, when they were beyond the limits which have been more or less definitely stated as requisite. On the other hand, the results which are given do not represent the best yields obtained; they are those which seem to be most instructive.

The experimental work has been seriously handicapped in one particular. With only one set of experiments (those recorded in Table VIII) has it been possible to maintain a temperature constantly between 50° and 60° F. Unfortunately a north basement room which gave those results during the winter of 1903–4 has not since been available for the work. The results are, however, comparative when not absolute.

The results given in Table VIII are referred to in various parts of this bulletin. Attention should be directed to the fact that many of these beds were yielding well when the experiment was necessarily closed to make room for a second series of experiments planned during the same winter. Beds Nos. 6, 9, 13, 25, and 40, for instance, each yielded between 8 and 15 ounces the day the experiment was closed, while beds Nos. 2, 10, 14, 23, 26, 30, and 37 each yielded 1 pound or more on the same day.

It is to be noted that a considerable number of beds in this series produced more than 1 pound per square foot, and some nearly 2 pounds for a similar area. It is certain that some beds would have yielded more than 2 pounds if they could have been permitted to produce longer.

TABLE VIII.—*Yields of experimental mushroom beds.*

Number of the experimental bed.	Material used in the bed.	Source of the spawn.	Number of days to produce mushrooms.	Yield in ounces first 30 days.	Yield in ounces second 30 days.	Total yield in ounces at close of experiments.	Area in square feet per bed.	Yield in ounces per square foot.
1	Fermented horse manure.	Alaska, old	27	53	54	107	6	18.0
2	do	Old American made	104	20	.....	20	6	3.6
3	do	English, current year market product.	51	7	.....	7	6	1.0
4	do	English, 2 years old	.....	.....	.....	0	6	0.0
5	do	English, 1 year old	.....	.....	.....	0	6	0.0
6	do	Alaska, U. S. Department of Agriculture.	51	47	68	115	6	18.8
7	do	Bohemia, U. S. Department of Agriculture.	53	48	17	65	5	13.0
8	do	Mixed varieties, U. S. Department of Agriculture.	51	78	34	112	6	18.6
9	do	Bohemia, U. S. Department of Agriculture, light spawning.	68	102	.....	102	6	17.0
10	do	Bohemia, U. S. Department of Agriculture, heavy spawning.	46	71	65	136	6	22.6
11	do	*Agaricus amygdalinus*, old	.....	.....	.....	0	6	0.0
12	Fermented horse manure (bed left for 2 months before being spawned).	Bohemia, U. S. Department of Agriculture.	61	5	.....	5	6	0.8

TABLE VIII.—*Yields of experimental mushroom beds*—Continued.

Number of the experimental bed.	Material used in the bed.	Source of the spawn.	Number of days to produce mushrooms.	Yield in ounces first 30 days.	Yield in ounces second 30 days.	Total yield in ounces at close of experiments.	Area in square feet per bed.	Yield in ounces per square foot.
13	Fermented horse manure.	Bohemia, U. S. Department of Agriculture.	49	110	50	160	6	27.7
14								
15	....do	....do	61	241	40	281	12	23.4
16	Leaf mold	*Calvatia cyathiforme*				0	6	0.0
17	....do	Bohemia, U. S. Department of Agriculture.				0	6	0.0
18	Fermented stable manure; bed fairly compact.	Alaska, U. S. Department of Agriculture.	48	118	71	189	9	21.0
19	Fermented stable manure.	....do	53	93	30	123	6	20.5
20	....do	Bohemia, U. S. Department of Agriculture.	48	101	39	140	6	23.3
21	....do	Var.?, U. S. Department of Agriculture.	53	96	37	133	6	22.2
22	....do	American commercial more than 1 year old.				0	6	0.0
23	....do	American commercial, Bohemia	53	111	53	164	8	20.5
24	....do	....do	51	46	67	113	9	15.2
25	....do	Bohemia, U. S. Department of Agriculture. Loose cakes; dried.	46	22	50	72	6	12.0
26	....do	Bohemia, U. S. Department of Agriculture. Watered freely late.	49	74	75	159	6	26.6
27	....do	Bohemia, U. S. Department of Agriculture. Watered freely.	49	42	51	93	6	15.5
28	....do	Bohemia, U. S. Department of Agriculture.	46	89	30	119	6	19.8
29	....do	....do	55	90	55	145	8	18.1
30	Fermented stable manure and 5 pounds cotton-seed meal.	....do	51	129	146	275	9	30.5
31	Fermented stable manure.	English commercial, St. Louis				0	6	0.0
32	....do	English commercial, New York				0	6	0.0
33	....do	Bohemia, Americal commercial	42	70	32	102	6	17.0
34	....do	Alaska, American commercial	46	70	31	101	6	16.7
35	....do	French, commercial flake				0	8	0.0
36	Fermented stable manure and cotton-seed hulls.	Bohemia, U. S. Department of Agriculture.	53	47	96	143	9	15.9
37	Fermented stable manure: bed heavily compressed.	....do	61			104	6	17.3
38	....do	Var.?, U. S. Department of Agriculture.	46	58	46	104	6	17.3
39	Fermented stable manure and sphagnum.	....do	46	11	11	22	6	3.7
40	Fermented sheep manure.	....do	50	44		44	6	7.3
41	Fermented stable manure, cotton-seed hulls, and cotton-seed meal.	....do	46	18	39	57	8	7.1
42	Fermented cotton-seed hulls and cotton-seed meal.	Bohemia, U. S. Department of Agriculture.	55			5	9	0.6
43	Manure mold	....do				2	6	
43	Sod	*Calvatia cyathiforme*. Pure cultures.				0	6	0.0
45	Old compost, left 2 months before spawning.	Bohemia, U. S. Department of Agriculture.	52			5	9	0.6

The series of experiments outlined in Table IX followed directly upon the series given in Table VIII. The beds in the first series were made in midwinter, and as the manure had been well fermented there was little or no rise of temperature after the beds were made. The spawn was therefore inserted at an unusually low temperature. During thaws in the late winter there was considerable seepage through the walls of the room. Some of the wall beds—Nos. 14 to 21—were seriously damaged, but although beds Nos. 7 to 13 were also wall beds seepage was not evident in this region. Within about thirty days after vigorous mushroom production began in this series the basement was flooded, and the work was therefore brought to an abrupt close. The yield up to that time is given, however, since in this series there are included many fertilizer tests.

TABLE IX.—*Yields of experimental mushroom beds in a north basement room, 1904.*

Number of the experimental bed.	Bedding material and fertilizer.	Spawn used.	Number of days to first picking.	Yield, in ounces, per bed.	Area of bed in square feet.
1	Stable manure and cotton-seed hulls.	Bohemia, U. S. Department of Agriculture.	48	33	6
2	do	do	48	94	6
3	Leaf mold and stable manure	do	48	38	6
4	do	do	48	36	6
5	Stable manure and sphagnum	do	61	4	6
6	Stable manure and cotton-seed meal.	do	61	64	6
7	do	do	66	73	6
8	Stable manure, timothy fed	do	73	2	6
9	do	do		0	6
10	Stable manure, clover fed	do		1	6
11	do	do		3	6
12	Stable manure, bran fed	do	66	84	6
13	do	do	54	109	6
14[a]	Stable manure, corn fed	do	71	12	6
15[a]	do	do	68	8	6
16[a]	Stable manure, oats fed	do		3	6
17[a]	do	do	80	14	6
18[a]	Stable manure	do	71	24	6
19[a]	do	do	66	40	6
20[a]	do	do	71	17	6
21[a]	do	do	68	55	6
22	do	do	48	61	6
23	Stable manure and complete fertilizer: KCl, 1 ounce; KNO_3, 1 ounce; bone meal, 7 ounces.	do	64	55	6
24	Stable manure and incomplete fertilizer: $NaNO_3$, 1 ounce; bone meal, 7 ounces.	do	64	30	6
25	Stable manure and NaCl, 2 ounces.	do	66	41	6
26	Stable manure and $NaNO_3$, 2 ounces.	do	48	42	6
27	Stable manure and $MgSO_4$, 2 ounces.	do	66	39	6
28	Stable manure and K_2SO_4, 2 ounces.	do	64	46	6
29	Stable manure and kainit, 4 ounces.	do	64	62	6
30	Stable manure and $CaCl_2$, 2 ounces.	do	64	48	6
31	Stable manure and Na_2HPO_4, 2 ounces.	do	64	65	6
32	Stable manure and $(NH_4)_2SO_4$, 2 ounces.	do	54	41	6
33	Stable manure and $NaNO_3$, 1 ounce; kainit, 2 ounces.	do	68	30	6

[a] Some of the beds in this block—Nos. 14-21—were seriously injured by seepage water, and the results are untrustworthy.

TABLE IX.—*Yields of experimental mushroom beds in a north basement room, 1904*—Continued.

Number of the experimental bed.	Bedding material and fertilizer.	Spawn used.	Number of days to first picking.	Yield, in ounces, per bed.	Area of bed in square feet.
34	Stable manure	English commercial (ordered as fresh).	68	84	6
35	do	Spawn from bed in full bearing	66	12	6
36	Stable manure, lime dressing	Bohemia, U. S. Department of Agriculture.	68	8	6
37	Stable manure, ammonium molybdate, ½ ounce.	do		(?)	6
38	Stable manure, $ZnNO_3$, 1 gram	do		(?)	6
39	Stable manure	*Agaricus amygdalinus*	68	7	6
40	do	Bohemia, U. S. Department of Agriculture.	64	77	6
41	do	English commercial (New York)	77	4	6
42	do	Bohemia, U. S. Department of Agriculture.	64	38	6
43	do	Spawn from old bearing bed		0	6
44	do	*Pleurotus ostreatus*		0	6
45	do	English commercial (Philadelphia)		0	6
46	Stable manure and sawdust	Bohemia, U. S. Department of Agriculture.		0	6
47	Stable manure	Var.?, American commercial	48	60	6
48	do	Alaska, American commercial	64	22	6

From the experiments given in the foregoing table further proof is furnished of the fact that stable manure alone, when of good quality, is sufficient for the growth of mushrooms. The addition of nutrient salts as fertilizers has not, on an average, given any marked increase in yield, but rather the contrary. It is hardly possible that the quantity of salts used on the beds was too little to make the effect felt. On the other hand, it was not sufficient to be injurious. It is evident from the experiment in bed No. 29, for instance, that the addition of 4 ounces of kainit could not have been injurious. In some instances the results obtained by the use of fertilizers were poorer than where the manure alone was used. This, however, the writer believes to be due largely to differences in the spawn used, or the differences in condition owing to the location of the bed, for subsequent experiments with some of the salts which seemed to be either injurious or beneficial have not wholly confirmed these results. It is to be noted, however, from the experiment in bed No. 6 of this series and also from bed No. 30, in Table VIII, that the beds treated with cotton-seed meal have invariably yielded somewhat above the average. These beds do not come into bearing quite so rapidly as those in which manure alone is used. It is thought that this is due to the fact that bacterial action is at the beginning more rapid in beds containing cotton-seed meal, and that, consequently, when this wave of bacterial growth has passed the nutrition of the spawn is favorably affected. Experiments had already indicated that manure

from animals which were fed a poor diet, such, for instance, as grass or hay alone, is much less valuable than where the animals are well fed. The experiments in beds Nos. 10 to 22 were designed to test the value of some different feeds. The writer was fortunate in being able to secure manure from work animals which were being used in feeding tests where very different foods were employed. Unfortunately, however, the mushroom beds were located next to a basement wall, and in beds Nos. 14 to 21 the results were vitiated by the fact that there was considerable seepage water in that region during the thaws and heavy rains of the spring. Nevertheless, it is believed that the experiments in beds Nos. 8 to 13 are trustworthy. An attempt was made to check these results by using some of this manure in tube cultures, and it was found that the manure used in beds Nos. 8, 9, 10, and 11 particularly was unfavorable for the growth of the mycelium even in the pure cultures.

On account of its stimulating action upon the spores of *Agaricus campestris* a small quantity of ammonium molybdate was applied to one bed, No. 37, in order to test its effect upon the growing mycelium. Moreover, since certain salts of zinc at considerable dilution have been found to increase greatly the quantity of mycelium produced by other fungi, zinc nitrate was employed in an adjacent experiment. The results of these two tests were the same. There was a profuse mycelial development and an abundant production of small deformed sporophores.

Table X also summarizes a series of some interest. These beds were spawned early in November, 1904. Soon after the spawn began to spread throughout the beds—about December 15—the temperature of the room fell to 40° F. From that time on until March 1, 1905, the temperature was constantly below 52°, and on several occasions as low as 32° F. After two or three weeks of warmer weather the beds began to bear vigorously, and the mushrooms, particularly the first ones, were of unusual size and of excellent flavor. Numerous individuals weighed from 6 to 8 ounces immediately after the separation of the ring, and a few mature specimens ranged from 10 to 14 ounces.

TABLE X.—*Yields of experimental mushroom beds—Third series.*

Bed No.	Material constituting bed.	Spawn used.	Comparative yield per bed, in ounces.
1	Stable manure	English commercial, 2 years old	0
2	do	Columbia, "green" spawn, U. S. Department of Agriculture.	70
3	do	Poor grade English commercial, recent importation.	16
4	do	Good grade English commercial, recent importation.	49
5	do	Good grade English commercial, 6 months old.	40
6	do	American commercial	57
7	do	do	34
8	do	do	54
9	do	U. S. Department of Agriculture, Columbia.	56
10	Rotted sawdust and stable manure	do	31
11	Leaves and stable manure	do	30
12	Sawdust	do	3
13	Leaves	do	6
14	Stable manure	American commercial, probably *A. arvensis*, var.	60
15	do	American, *A. villaticus*	68

In some publications on mushroom growing the claim is made that old or practically exhausted beds may be brought into bearing again by heavy fertilization with liquid manure or with a weak solution of potassium nitrate. From a commercial point of view, no measurable success has resulted from any trials of this nature made by the writer; consequently, it is believed that exhausted beds should be immediately discarded. From the standpoint of mushroom sanitation, this is also particularly desirable.

VARIABILITY IN MUSHROOMS GROWN UNDER DIFFERENT CONDITIONS.

The writer does not intend to discuss even in a general way the relationships of the various forms of Agaricus—that is, those that may be considered allies of *A. campestris*—which he has cultivated or studied in the field. Some reference to the variability of common forms should, however, be made. For a comprehensive study of species and varieties, a knowledge of European forms as well as of those found in America is essential. Authors differ so widely in their descriptions of species, as well as in their conceptions of them, perhaps, that in the absence of unlimited material nothing short of confusion results from any attempt to harmonize opinions. It is sufficiently difficult to separate what many would regard as varieties of *A. campestris* from those of *A. arvensis*. When specific rank is bestowed also upon such forms as *A. pratensis*, *A. villaticus*, *A. magnificus*, *A. rodmani*, etc., the difficulties are greatly increased. The writer has grown many forms of Agaricus, and, as might be expected, there seems to be no form which will remain practically constant under variable conditions. Besides general size, size of spores, etc.,

some of the characters used in separating the common forms are color of gills; character of ring, particularly as to whether single or double; shape of stipe; color and markings of pileus; color of flesh, etc. In following the development of these characters in different forms, many variations will be found. *Agaricus campestris* grown on composted leaves shows very little pink in the gills. The color changes rapidly from dull pinkish-brown, or almost white, to a leaden hue. Several brown-capped forms, usually considered varieties of *A. campestris*, never show a bright-pink surface unless produced under exceptionally favorable conditions, moist air being a sine qua non. The ring is naturally variable. In any variety of *A. campestris* it is not uncommon for an edge of the partial veil to remain attached to the base of the stem as a volvate line, or this line may be left at any stage during the elongation of the stem. Again, if the lower margin of the partial veil on the stipe separates slightly from the stipe, and upon drying curves slightly upward, there is an indication of a double ring. A very good double ring appeared on a number of very vigorous specimens of an undoubted variety of *A. campestris* during the present season. It is possible that there is a greater tendency to produce a double ring when conditions are favorable for the production of the most vigorous mushrooms. *Agaricus arvensis* is also very variable with respect to the formation of a double ring, as also in the persistence of the partial veil.

The shape of the stipe is in many forms dependent upon the conditions. Under favorable conditions a brown variety of *A. campestris* may have a very short, thickened, equal stem, when grown on manure, and practically uniform at maturity, while the same form grown on decayed leaves may show in the main a stipe with thickened base, gradually tapering to the top. The color of the cap is of undoubted value as a varietal or specific character, yet it must be remembered that whether the surface be smooth or rough, merely fibrillose, or broken into scales of definite form, may depend entirely upon whether produced in moist air or in dry air, subjected to drying after being wet, etc. The color of the flesh is also dependent, to a considerable extent, upon the conditions. A specimen grown in even fairly unfavorable conditions will show the flesh somewhat darkened, and on exposure the characteristic pink tint will not be even momentarily visible. In other words, a considerable range of variation must be anticipated, and in comparisons there should be stated very clearly the conditions under which the particular forms are produced.

THE CULTIVATION OF VARIOUS SPECIES OF MUSHROOMS.

In Table X are given the results of a single test with *Agaricus arvensis*, or what is supposedly a brown variety of this species, and

also of a single experiment with *A. villaticus*. In both cases the yield was excellent. It is not well to draw definite conclusions from individual tests, but it is believed that both of these forms will yield profitably in general culture under conditions similar to those required for *A. campestris*. Plate III, figure 2, indicates the size and compactness of the mature sporophore of *A. villaticus*. Moreover, both of the species above referred to are to be recommended for texture and flavor. Two forms of *Agaricus fabaceus* (see Pl. III, fig. 1), both with amygdaline odor and flavor, have been tried in relatively few experiments. In no case has the yield been very good, and further experiments will be required before it will be possible to state under what conditions these forms may be most successfully grown. At the Missouri Botanical Garden Prof. William Trelease has for some time grown successfully one of these varieties.

Owing to the profuse and rapid growth of the mycelium of *Coprinus comatus* in pure cultures, it was anticipated that it might easily be grown in beds. The few experiments thus far made indicate that in impure cultures (beds) of leaf mold the mycelium grows and spreads very slowly. Hot weather prevented the maturity of the tests, but no sporophores were produced during a considerable period. In similar experiments *Lepiota rhacodes* and *Tricholoma personatum* were used. The former has given unsatisfactory results thus far, but the latter is promising.

It is not yet time to report on the possibility of growing the better and larger species of puffballs and the morel. It has already been indicated that the mycelium of these fungi grows well in pure cultures. From the pure cultures it has also been demonstrated that spawn may be made, but it has not been determined under what conditions the fruit may be produced. Figure 1 on Plate IV shows a young specimen of one of the puffballs, *Calvatia craniiformis*, the spawn of which is produced with the least difficulty.

COOPERATIVE EXPERIMENTS.

During the winter of 1902–3 a small quantity of experimental spawn made by the writer was sent out to mushroom growers for trial; in 1903–4 this spawn was made in large quantity, and trial packages were sent to more than 100 growers or interested persons. At that time Farmers' Bulletin No. 204 had not been issued, and the instructions which could be furnished inexperienced growers were inadequate. Nevertheless, an attempt was made to obtain reports from all persons receiving the experimental spawn, even from those who had applied for and received spawn when the season was too far advanced for successful work except in caves and cool cellars. A number of reports were received, but, as might be expected, fully 50 per cent of these indicated that the conditions under which the experi-

ments were made were wholly unsatisfactory, and that, therefore, no favorable results could be anticipated. Among those whose reports indicated that the conditions were favorable, or fairly favorable, only a small percentage reported failures, while four-fifths of those claiming success secured yields of more than one-half pound per square foot of bed space, many obtaining more than 1 pound per square foot. In two instances a yield of nearly 2 pounds to the square foot was reported. The frontispiece, Plate I, a bed in full bearing, and Plate VII, figure 1, showing the mushrooms as prepared for market, are photographs furnished by cooperating growers who are now also making spawn of pure-culture origin. It was suggested to growers who received the experimental spawn that a comparative test of the English or other commercial spawns with that received from the Department of Agriculture would be of interest. Comparative tests were made and reported by 10 growers. In most cases the English spawn, obtained at random on the market, failed to grow. In only one case did the English spawn prove better than the pure-culture product, and in this instance the spawn furnished by the Department when used was nearly one year old.

Failures may always be anticipated when attempts are made to grow mushrooms under adverse conditions, and it must be said that greater success was obtained from the cooperative work than could have been hoped for, considering the fact that many of the persons who sent in reports were wholly inexperienced and were practically unguided.

During the present year experimental mushroom spawn has been sent to more than 200 interested persons, and this will doubtless be the last general distribution of this product by the Department of Agriculture. Representing the varieties of *Agaricus campestris* commonly grown, mushroom spawn of pure-culture origin is now an established market product. In order that the standard of the American spawn may be maintained, spawn makers, dealers, and growers should see to it that only the fresh, recently dried product is used.

Nevertheless, it is hoped that this cooperative work may be carried forward, looking toward the development of better varieties or the bringing into culture and the testing of new species.

CAVE FACILITIES IN THE UNITED STATES.

Cave facilities in the United States are by no means so meager as has been supposed. There are in some sections caves from which rock for Portland cement has been mined. Some of these have been utilized for mushroom growing. There are also natural caves of great extent in many of the States of the Central West—especially

in Indiana, Missouri, Kentucky, and Arkansas—as well as in Virginia.[a] The difficulty is to obtain caves within a convenient distance from cities, for stable manure becomes expensive if it must be hauled many miles or transported long distances by the carload. Again, caves should be easy of access, since after each crop every vestige of soil, manure, etc., of the preceding crop must be removed as a sanitary precaution. This is especially necessary since there is much waste space in most natural caves, and it becomes a very difficult or expensive matter to fumigate. If the cave system is extensive, it must also be possible to give it thorough ventilation. Many natural caves are the courses of subterranean streams. The latter are by no means objectionable if there is no danger from overflow. In many caves the stream has long since found a new channel and the cave is dry. Seepage water, usually accompanied by continuous stalactite and stalagmite formation, is undesirable. In some of the Eastern States coalpits or coal mines may be important for mushroom purposes. Where the coal mine is not too deep, or where perfect ventilation may be given, there is no reason why it is not entirely suitable for mushroom growing.

OPEN-AIR CULTURE.

In some sections of England and France open-air culture of mushrooms in beds is practicable during the late autumn and winter months, in which case the productive period may extend into the spring. The difficulties in the way of open-air culture are not merely those of maintaining a more or less uniform temperature, but also of maintaining practically constant conditions of moisture. For these reasons it is necessary to mulch the beds heavily with clean straw. In some instances a light mulch of straw is permitted to remain even during the period of production, for a rapid drying out of the surface would be hazardous or fatal. It is better, perhaps, to put the beds under some form of protection, such as an improvised cold frame.

In regions where the climatic changes are marked, open-air culture is probably not to be recommended during any season for commercial purposes. It is probable that there are some areas in the United States in which open-air culture might be practiced with profit. It has seemed that certain sections of California might be favorable for this phase of the work. In the interest of experiments

[a] The writer is indebted to Prof. C. F. Marbut for the information that caves are to be expected in the Silurian limestone, which occurs particularly in the extension of the Shenandoah Valley, in the bluegrass region of Kentucky, and in the Ozark region of Missouri and Arkansas; also in the Lower Carboniferous limestone, which extends into Indiana, Kentucky, Tennessee, and Missouri.

along this line the writer has made a special attempt to acquaint himself with the conditions in that section of the country. This has seemed particularly desirable, inasmuch as fresh mushrooms could not be shipped to the far West from sections in which they are at present grown in quantity. From the information obtained it is thought that successful open-air mushroom growing might be anticipated in those sections where the average temperature is between 48° and 55° F., provided there are relatively few days when the temperature falls as low as 32° F. At the same time, open-air culture can not be recommended for those sections in which dry winds are prevalent. As a rule, during the wet or winter season the rainfall is so light that heavy mulching would probably suffice to prevent injury from excessive wetting. Nevertheless, it seems apparent that even in regions most favorable for open-air culture some inexpensive partial protection against the changes of temperature due to direct sunlight, or against heavy rainfall, would be desirable.

It was also ascertained that *Agaricus campestris* appears naturally in some quantity during the months of January and February, or longer, during the rainy season. This, however, is also true of other species of fleshy fungi. The large size of some of the specimens of *Agaricus campestris* and *A. arvensis* found would seem to suggest that they were produced from an unusually vigorous mycelium. This may be the result of a condition analogous to that previously mentioned, where, on account of the low temperature of the atmosphere, the spawn may develop slowly through a considerable period, and finally, under favorable conditions, sporophores of unusual size are produced.

In the following table are given the monthly mean temperatures from several representative stations in California during the years 1899 and 1900. From this table it will be seen that so far as the mean temperature is concerned Eureka and San Francisco would be especially favorable during a large portion of the year. Independence and Red Bluff are likewise satisfactory, while San Luis Obispo, Santa Barbara, Los Angeles, and San Diego show a mean which is perhaps rather too high. The moisture of the atmosphere, the prevalence of hot winds, the variation in the daily temperature, and the number of hot or cold days must all be considered. From the data obtained, the general conclusion seems to be that the most favorable regions are those where conditions correspond closely to those of Eureka and San Francisco. This, however, represents a large region, including a considerable portion of the San Joaquin and of the Sacramento valleys. In a few places experiments have already been undertaken to determine the possibilities for the development of this work, but no definite recommendations can be made until the experi-

mental evidence is at hand. It may be said, moreover, that some of the regions which seem to be too warm for open-air culture may be especially favorable during several months at a time for mushroom growing in ordinary cellars, or in very simply constructed mushroom houses. In those sections the winter and early spring months would doubtless give the most satisfactory conditions; and this period, fortunately, corresponds with the tourist season—a season when the market demands are greatest. It is also possible that with mulching and with simple protection, mushroom growing may be successful in some of the Eastern States.

TABLE XI.—*Mean monthly temperatures at points in California, in degrees Fahrenheit.*

Month.	Eureka.		San Francisco.		San Luis Obispo.		Santa Barbara.	
	1899.	1900.	1899.	1900.	1899.	1900.	City.	F.H.S.[a]
January	47.5	50.4	53.0	50.7	54.2	56.2	53.0	55.4
February	44.4	48.6	51.6	53.6	54.4	56.2	54.6	58.0
March	48.0	50.5	52.2	55.2	54.0	58.2	55.3	57.4
April	48.2	50.0	54.6	54.0	56.4	54.2	57.9	59.3
May	49.6	54.4	52.6	57.0	54.0	61.6	59.4	59.4
June	52.0	56.2	56.9	57.6	62.4	63.9	62.6	64.4
July	54.8	56.4	55.9	58.2	64.4	64.2	65.5	68.1
August	55.9	57.0	58.3	59.7	64.0	64.9	66.9	68.9
September	54.8	56.6	58.2	63.3	65.5	64.4	66.1	69.9
October	52.0	53.8	59.3	58.8	59.6	62.8	62.6	64.8
November	55.9	53.3	56.8	56.3	57.4	59.8	59.1	64.7
December	48.0	50.8	49.6	50.2	54.3	55.6	55.6	58.4
Year	50.9	53.2	54.9	56.2	58.4	60.2	59.9	62.3

Month.	Los Angeles.		San Diego.		Independence.		Red Bluff.	
	1899.	1900.	1899.	1900.	1899.	1900.	1899.	1900.
January	56	58	56.0	57.1	40.2	46.6	48.8	48.8
February	54	58	53.4	57.2	46.5	48.1	51.6	51.1
March	57	60	56.4	59.1	50.5	54.9	52.2	58.6
April	60	57	58.0	57.1	59.4	52.0	60.8	57.6
May	60	64	58.0	60.6	60.0	65.8	63.2	67.0
June	65	67	61.4	63.9	74.2	75.4	77.9	76.8
July	70	71	65.6	67.1	80.4	79.4	82.0	82.6
August	69	68	65.8	65.7	72.6	72.4	73.8	77.0
September	70	67	65.5	65.3	74.6	63.5	78.0	69.9
October	63	64	62.7	62.8	55.4	58.8	61.0	60.0
November	62	66	61.0	63.7	49.4	50.4	54.4	54.8
December	58	60	58.7	59.7	43.1	43.4	45.5	45.4
Year	62	64	60.2	61.6	58.9	59.2	62.4	62.5

[a] Foothills or suburbs of Santa Barbara, at an elevation of 750 feet above the city.

Occasionally one reads of successful natural cultures of mushrooms; that is, the production of this plant in pastures, lawns, etc., under more or less natural conditions. At Columbia, Mo., the writer has made numerous attempts to spawn plats in pastures and lawns; but thus far failure has attended every attempt. The spawning has, moreover, been tried at every season of the year. It is believed that in the section of the country mentioned only exceptionally favorable seasons will permit any success in this phase of open-air culture.

MUSHROOM SPAWN MAKING.

The mycelium of the cultivated mushroom has long been known commercially as "spawn." From early times it has been recognized that mushrooms may be grown from spawn, and it is quite certain that in all attempts to propagate mushrooms spawn has been used for the purpose.

In France, in England, and in other countries in which the mushroom has long been grown it is recognized that it is not profitable continually to take growing spawn from one bed to be preserved as "seedage" for the next crop. The common expression is that the spawn "runs out" in about three years. There seem to be few or no definite experiments indicating the exact conditions under which the spawn in two or three years loses the power of vigorous mushroom production. Nevertheless, it is the almost unanimous opinion of all extensive growers that there is a marked diminution in the yield after several successive propagations from the spawn in the mushroom bed. This has seemed to be true in the writer's experiments, although it must be said that accidents to experiments undertaken have made it impossible to report at this time upon the nature of this running out. That deterioration does result is apparently a fact accepted by all scientific men who have given attention to mushroom growing. It is possible, however, that under certain conditions the spawn might be repeatedly propagated without loss of prolificness. It is not necessary to enter here into a discussion of possibilities or to attempt to explain why weakening might be evident under ordinary conditions.

A "chance" method.—For practical purposes it is necessary to renew the spawn and to secure, if possible, spawn which has not previously weakened itself by the production of mushrooms—known as virgin spawn. Natural virgin spawn may be found wherever "in nature" it has been possible for the spores to germinate and to produce a mycelium. Ordinarily such so-called "spontaneous" appearances of spawn may be anticipated in compost heaps, rich garden beds, pastures near the feeding places of animals, etc.

Many attempts have been made by practical growers to develop spawn from spores, sowing the gill portions of mature mushrooms in specially constructed beds; but the results, so far as the writer is aware, have not been satisfactory. As a rule, therefore, growers have been compelled to rely wholly upon a virgin spawn which has been obtained by chance. It is said that in the vicinity of Paris some persons make a business of searching for this virgin spawn, which they sell to the growers at a high figure. It is claimed that they become so adept in detecting the differences in the character of growth, the quality of odors, etc., that they can distinguish not only

Agaricus campestris, but also some of its varieties. In England much of the virgin spawn has been obtained from pastures. Where a "spontaneous" growth of spawn is observed, trenches are dug, and these are filled with good stable manure. The latter in time becomes penetrated, and it is highly prized for cultural purposes. As a rule, the virgin spawn is used in spawning beds, which, when well penetrated, are torn down, and the whole bed used as flake spawn in spawning the general crop. Again, the virgin spawn may be used in spawning the brick, or cakes, this being the form in which English spawn is usually made. However adept persons may become in the identification of various varieties of spawn by odor, etc., this must be considered essentially a chance method.

A "*selective*" *method*.—From what has been said it will be perceived that very little advancement could be made in the selection of desirable varieties of mushrooms, in varietal improvement and the like, so long as the chance method of securing spawn should prevail. The studies in the germination of mushroom spores previously referred to were encouraged by the apparent necessity of beginning with spores from mushrooms of known qualities in order to effect improvement. In recent years the investigations of Costantin [a] upon spore germination have found application in a department of the Pasteur Institute. By a secret method, mycelium is grown from the spores in pure cultures. These cultures, which are, of course, pure virgin spawn, are then offered for sale to the growers. This spawn does not seem to have received deserved consideration on the part of the growers. The secret method of effecting spore germination referred to by Répin [b] has also been practically applied by one of the largest seed firms in Paris. In general, however, French growers have not profited so much by the new methods, perhaps partially on account of the fact that these methods are not known and partially because of the expense of the new virgin spawn. It is to be noted that these methods imply pure cultures to begin with.

The successful germination studies with chemical stimulation mentioned in this paper were soon overshadowed by the discovery of the ease of making tissue cultures. The use of the latter method has been the means of a sudden advancement in spawn making in this country during the past two years, for many practical men have been quick to see the advantages which it offers.

Pure-culture precautions.—It has already been stated that the pure-culture method of making virgin spawn is not one which will prove successful in the hands of wholly inexperienced persons, or of those who are unwilling to spend time and use the utmost care in the manipulation of the cultures and the culture material. The use of

[a] Costantin, J., loc. cit.

[b] Répin, C., loc. cit.

pure-culture methods necessitates to a considerable extent a knowledge of the bacteria and molds which are everywhere present in the air and which are especially abundant wherever there are dusty or damp, moldy conditions. The principle of making pure cultures is briefly this: The materials, or media, and all the vessels employed must be sterilized, which implies being heated at a temperature sufficient to kill all germs present in the vessels or materials used. If the vessels used are test tubes or other pieces of glassware with small mouths, they should, previous to sterilization, be plugged with cotton batting. This cotton batting prevents, when carefully manipulated, the entrance of germs from the air, and therefore keeps the vessel or medium in a pure or sterile condition. If such a vessel is opened, this should be done in a room free from currents of air or falling dust particles; and, while open, tubes and other apparatus should be held in a more or less horizontal position, so that they will be less liable to contamination. It follows, of course, that the cotton plug, if removed, should not come in contact with any unsterilized substances. If, now, a small quantity of the growing mycelium of a mushroom from a pure culture is transferred to such a sterilized tube, using for this transfer sterile needles, or scalpels, there will be little danger from foreign organisms, and the piece of mycelium inserted will therefore grow as a pure culture free from all other fungi or bacteria.

The tissue-culture method.—In making pure cultures of mushrooms, large test tubes or wide-mouthed bottles may be used. These should be carefully cleaned, and, if possible, a sterilization should be given by means of dry heat as a preliminary precaution. In this event the tubes are plugged with cotton plugs and placed in a dry oven made for the purpose. They are heated to a temperature of about 150° C., and this temperature should be maintained for nearly an hour. Ordinarily, however, in rough work it is not essential to employ this preliminary sterilization. In either case the tubes are next partially filled (about two-thirds) with the manure, or half-decayed leaves, upon which it is desired to grow the virgin spawn. A plug is inserted in each tube, and the tubes are then sterilized in a steam boiler or under pressure. If sterilized under steam pressure, as in an autoclave, it is necessary to use about 15 pounds pressure and to allow the tubes to remain at this pressure for from fifteen minutes to half an hour. If the sterilization must be effected in a boiler or in an open water bath, it can only be done at 100° C., of course; and it is then desirable to boil the tubes for at least one hour on each of two or three successive days.

With the tubes thoroughly sterile, the next step is to make the cultures or inoculations. By the tissue-culture method it is implied

that the inoculations are made from pieces of the tissue of a living mushroom. It is at this stage that selection may be made. One should procure from a bed of mushrooms in full bearing a mushroom which represents the most desirable qualities that are to be found. Size, quality, and general prolificness must all be considered, as well, also, as other characteristics in any special selections. One may desire, for instance, to select from a variety which yields throughout a long period—one which is resistant to higher temperatures, etc. Having found the mushroom from which it is desired to propagate, plants as young as possible may be used, and those which show the veil still intact are especially desirable. With a scalpel, or a pair of forceps, which has been sterilized by passing the blade through a gas flame, or even the flame from an alcohol or ordinary lamp, small pieces of the internal tissue may be removed, and these pieces transferred to the tubes, without, of course, coming in contact with any object whatever which has not previously been sterilized. It is a good idea to wash the mushroom first, so that no dust will be made. The plant may then be broken open longitudinally and bits of the internal tissue readily removed without fear of contamination when one becomes adept in this kind of manipulation. Immediately upon inoculation the cotton plug is replaced in the tube, and after all the tubes are inoculated they should be put out of the dust, preferably in a situation where the temperature is about that of an ordinary living room. In the course of several days a slight growth may be evident from the tissue if the conditions have been perfectly sterile. In the course of a week or more the growth should become very evident, and in three weeks the moldlike development of mycelium should spread to practically all parts of the medium in the tube. The method of making pure cultures and the laboratory apparatus usually involved are shown in Plate VI, figure 2.

When the tubes are thoroughly " run " the contents may be removed and used in spawning brick. The contents of a single tube may spawn several bricks when carefully employed. If no transfers are made of the growing mycelium from one lot of tubes to another, the writer has not found it at all impracticable or unfavorable to utilize this first lot of bricks later in spawning others. No further transfers, however, should be made from these bricks to others under any circumstances in spawn making. As elsewhere indicated, such a continuous transference is injurious to the vigor of the spawn and diminishes the quantity of mushrooms produced.

The commercial process.—The essentials in spawn making are (1) a uniform, compact manure brick; (2) vigorous and well-selected virgin spawn to be used in inoculating the bricks, and (3) favorable conditions for the storage of the bricks during the growth of the spawn.

It should be indicated that there is no one method of making brick spawn. The process may and will be varied by each spawn maker. Any skill or mechanical devices which will simplify or improve the process in any particular are to be recommended.

The materials entering into the composition of the brick are fermented stable manure, cow manure, and sometimes a small quantity of well-selected loam. Perhaps the chief value of these different constituents is as follows:

In the horse manure the mycelium grows most readily. The cow manure binds the materials together into compact brick. The loam, which is perhaps least essential, is supposed to prevent cracking or hardening of the surface, and therefore contributes to the appearance of the finished brick, at the same time tending to prevent rapid fermentation during growth. It also in some cases facilitates the uniform spread of the mycelium. If fresh manure is used, the necessity of using loam is perhaps to be emphasized.

In the experiments which have been made under the auspices of the Department of Agriculture these materials have been used singly and in various combinations, and it is beyond doubt that the relative proportions of these should be determined by the special conditions under which the spawn is made. Excellent results have been obtained by using a mixture of from two-thirds to three-fourths stable manure and the remainder cow manure. In this case the compost for the brick is subjected to fermentation previous to its use. When loam is employed it may be used in more or less equal proportion to the cow manure; and the quantity of stable manure should about equal that of the other two ingredients. If the straw present does not become sufficiently disintegrated during the preparation of the manure to enable one to make a smooth brick, it should be removed, in part at least.

The dry bricks ordinarily measure about 5½ by 8¼ by 1¼ (to 1½) inches. They should therefore be molded of somewhat larger size, perhaps 6 by 9 by 2 inches, since there is considerable contraction during drying. The mold consists merely of an oak frame of four pieces strongly riveted together. It may also be profitably lined with thin steel plates. In molding the brick one of two methods may be followed: (1) The compost may be thoroughly wet or puddled; then, with the mold upon a board of suitable width, the manure is compressed into it, the mold removed from the brick then formed, and the board pushed along for a succession of such impressions. The boards supporting the bricks are then disposed in racks and the bricks dried for a few days, or until they may be turned on edge for further drying out. (2) The compost may be used in a condition which is merely moist. It is compressed into the brick with some force, a mallet being often employed. The brick thus obtained is

sufficiently rigid to be immediately handled if necessary. By this method, unless the compost has been in excellent condition, the bricks are not so smooth as might be desired for commercial purposes. In some instances they have then been subjected to a repress process, an old repress brick machine being adapted for the purpose. In such cases the bricks are made thicker to begin with. The second method has been discontinued by some who at first employed it.

Two methods are also employed in spawning: (1) The more common method is to insert into the brick near both ends a piece of the virgin spawn obtained for the purpose. A cut is made with the knife, the spawn inserted, and a stroke of the knife effectively closes the surface. This must be done as soon as the brick can be readily handled. (2) The bricks are dried until merely moist throughout; then, on being piled, nocules of spawn are placed between successive bricks, a piece at each end. In either case the bricks are not piled for the growth of the spawn until in good condition as to moisture content. This should be determined not by the surface, but by the interior of the brick. In the pile the surface will soon become moist. When the first method is employed it is sometimes customary to spread between the layers of brick in the pile a little moist manure or sawdust. It has been determined, also, that the absolute moisture content of the brick should be about 40 per cent, which is the same as for the mushroom bed. Tests of the moisture content of bricks growing well have varied from 35 to 47½ per cent.

Occasional examination should be made to determine the temperature and the extent of growth. In order that the bricks may become thoroughly penetrated, more than a month will usually be required.

The most favorable conditions for the growth of the spawn are practically the same as for mushroom growing. A fairly moist atmosphere, maintained, if necessary, by spraying, and a more or less uniform temperature (55° to 60° F.) are to be preferred. The size of the piles will depend upon the other conditions; but if there is any danger of considerable fermentative activity the bricks should be so disposed as to permit perfect ventilation between two or more adjacent rows.

When the bricks are thoroughly "run" they are dried under cover before being shipped or stored in bulk, since in a moist brick the spawn would continue to grow and would soon produce small mushrooms or else would become moldy. Well-penetrated bricks of spawn are shown in Plate VII, figure 2. The areas of mycelial growth should be evident to the eye. The growth should be moldlike, however, rather than composed of very large threads or fibers.

The suggestion made in a previous publication that mushroom spawn should be sold by the brick (with a uniform standard of size) seems to have been adopted by American makers. The trade names

suggested for the common types of *Agaricus campestris* in culture have also come into use. It is certain that these names, Alaska, Bohemia, and Columbia, designating respectively a white, a brown, and a more or less cream-gray form, do not include all forms in cultivation. Until a careful study has been made of varieties, however, this nomenclature will enable spawn makers to keep in mind certain types, and will make it possible for growers to ask for a spawn yielding a color demanded by their special markets.

THE VITALITY OF MUSHROOM SPAWN.

Many of the early experiments in mushroom growing undertaken by the writer were made in the hope of being able to ascertain the more frequent causes of failure and some of the chief difficulties encountered by American mushroom growers. The ordinary commercial spawn used by amateurs, that is, such as is obtainable upon the market during the winter months, was purchased wherever possible. Samples of this spawn were placed under conditions which were supposed to be most favorable for growth. Nevertheless, in the majority of cases there was no indication of the development of a new mycelium from the bricks of spawn thus obtained. From these results it was suspected that much of the spawn which reaches the amateur grower may be considerably injured, or even killed, by transportation or improper conditions of storage; for it must be supposed that most of this spawn is in good or at least fair condition when exported from Europe.

Subsequently the writer was able to look into the matter of spawn making in Europe and France, and he was convinced that the difficulty of securing good spawn in England is not a very serious factor. The same is true with reference to the material which is obtained by both extensive and small growers in France.

Special importations of some of the commercial English and French spawns were made, and this was packed, shipped, and stored under conditions as favorable as may ordinarily obtain. This spawn was imported during midwinter and stored until March or early April, when it was used in spawning some experimental beds. The conditions of the experiments were practically the same throughout, yet in not more than half the beds was there a favorable development of mushroom spawn. A distribution of the French spawn, both the commercial flake and the improved cake spawn, was made to several prominent American growers. Some of these growers experienced entire failure, while others reported that, after a slow beginning, beds spawned with this material made a good yield. The general conclusion, reenforced by observation and by the experience of practical growers, could only be that a large percentage of loss in mushroom

growing is attributable to the injury suffered by the spawn after its preparation. This conclusion has been further strengthened by the experience of the past three years. From Table VIII, beds Nos. 1, 2, 4, 5, and 30, it will be seen that, under conditions where fresh spawn has invariably made a good yield, the spawn which is more than a year old is, for the most part, seriously injured or killed. To be exact, in only one case was there any production of mushrooms by spawn which had been kept for a year or longer. It must be said that no attempt was made to keep these spawns under similar conditions or under the most favorable conditions. For the most part the spawn was stored in the dry laboratory room, in which the temperature was more or less variable, but never extreme. The old American spawn which was used in experimental bed No. 1, in Table VIII, was stored in a basement room where the average temperature was undoubtedly cooler than that of the laboratory room.

From experimental beds Nos. 1, 3, 4, and 5, in Table X, it is again seen that old spawn is unreliable. In this particular case the material was furnished by a prominent mushroom grower—an English spawn importer. This spawn had been stored in a dry house and was therefore subject to similar conditions. In Table VIII, beds Nos. 31, 32, 35, and in Table IX, Nos. 34, 41, and 45, there is further proof of the loss of vitality in the imported spawn ordinarily offered for sale in many of our cities. In these cases spawn was bought on the market just as offered for sale to the amateur buyer; "best on hand" was asked for, but no stipulation was made that is should be of recent importation, and no guaranty was asked. The tests were not, therefore, to compare the very best English with the best American spawn, but merely to secure an indication of some of the causes of failure by the purchase at random of English and French spawn on the market. Even in times past the extensive mushroom growers have either imported their spawn direct, or made sure that they were obtaining the best product that the market could furnish. Unfortunately, it has not been possible to compare, in any experiments thus far concluded, the best English with the best American spawn.

The results seem also to indicate that brick spawn maintains its vitality longer than the flake material, and that brick spawn made of loose, light material is less retentive of vitality than that made after the formula commonly followed in England. This proves to be an unfortunate factor to be dealt with in the attempt to reduce by all means the weight of the brick. The reduction in weight would be most desirable, since freight upon this material adds considerably to the price of market spawn. To the poor keeping qualities of loose spawn is perhaps due the large number of failures with French flake spawn, and perhaps also some of the failures with the

newer form of French brick spawn. The latter is made in the form of very small, thin bricks, which are unquestionably more affected by weather conditions than the larger English bricks.

These results have seemed to demand that special attention should be given to methods of spawn making in the United States in order that growers might be able to secure this product as fresh as possible. Moreover, it was desirable, as previously indicated, to attempt work leading to the selection and improvement of varieties. The success of the work in spawn making has been almost all that could have been anticipated. By the pure-culture methods described several firms are now making grades of brick spawn which have yielded remarkably well. This fact is now thoroughly recognized by a large number of the best growers throughout the country. Probably as many as 50,000 bricks were sold during 1904, and it is perhaps to be expected that several hundred thousand will be sold during the present year.

It is to be regretted that it has not yet been possible to abandon the pure-culture process by means of which the virgin spawn is made while retaining the advantages of selection. Nevertheless, it should be remembered that the very difficulties of this process insure its use only by those who are able to give it their best attention and who will doubtless develop it to the fullest commercial extent. It has not been supposed by the writer that the work thus far accomplished will enable all mushroom growers to manufacture their own spawn with comparative ease. In other phases of horticultural work it is not so much to individual growers as to progressive seedsmen that we look for the best seed of improved varieties. The same thing apparently must be anticipated in the development of the mushroom industry. The growing of selected spawn may, in general, become a specialized process.

Nevertheless, it is believed that in time a method of spawn production from spores without pure-culture precautions will be developed. The necessity of developing immediately, or placing on a practical basis, the pure-culture process has temporarily directed the experimental work along other lines.

THE PHILADELPHIA
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MUSEUMS.

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FIG. 2.—MORELS (MORCHELLA ESCULENTA), ONE OF THE FINEST EDIBLE FUNGI.

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FIG. 2.—THE METHOD OF MAKING PURE CULTURES, SHOWING THE APPARATUS AND MATERIALS.

FIG. 1.—MUSHROOMS PREPARED FOR THE AMERICAN MARKET.

FIG. 2.—GOOD ("WELL-RUN") MUSHROOM SPAWN, BRICK FORM.

GENERAL VIEW OF THE OUED SOUF REGION FROM THE TOWN OF EL OUED, SHOWING SAND DUNES AND SUNKEN GARDENS OF DATE PALMS.

THE PHILADELPHIA
NOV 28 1905
MUSEUM.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 86.

B. T. GALLOWAY, *Chief of Bureau.*

AGRICULTURE WITHOUT IRRIGATION IN THE SAHARA DESERT.

BY

THOMAS H. KEARNEY,
PHYSIOLOGIST.

VEGETABLE PATHOLOGICAL AND PHYSIOLOGICAL INVESTIGATIONS.

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[a] Detailed to Seed and Plant Introduction and Distribution.
[b] Detailed to Bureau of Chemistry.
[c] Detailed from Bureau of Chemistry.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., September 6, 1905.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 86 of the series of this Bureau the accompanying paper, entitled "Agriculture without Irrigation in the Sahara Desert."

This paper was prepared by Mr. Thomas H. Kearney, one of the physiologists of this Bureau, and the data for it were obtained on a trip which he made to northern Africa for the Office of Seed and Plant Introduction and Distribution, primarily for the importation into the United States of offshoots of valuable Tunisian date varieties. It is believed that the methods described may be useful in some cases in our southwestern desert regions where date culture is being introduced.

The accompanying illustrations are necessary to a clear understanding of the text of this bulletin.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

PREFACE.

In view of the interest in farming without irrigation that is now being manifested in the arid portion of the United States, an account of a region where agriculture is carried on under extremely adverse natural conditions is particularly timely. The present paper deals with a highly developed system of date-palm culture in the Oued Souf, a remarkable and little-known part of the Sahara Desert in northern Africa. Strictly speaking, it is not dry-land agriculture with which we have to do in the Souf region, for while the rainfall is practically nothing and irrigation is impracticable, the roots of the trees quickly find their way to ground water. However, it is quite possible that similar conditions may be found to exist in this country in some parts of the desert region of the Southwest, and that the Souf system, with or without irrigation, can be utilized there on a small scale in growing certain orchard crops with a view to forcing fruit to early maturity, so that it can be put upon the market much in advance of the bulk of the crop.

The Oued Souf was visited by Mr. Kearney at the end of November, 1904, the journey having been made from Nefta, in southwestern Tunis, where he had spent several weeks in a study of the date palm. This expedition to northern Africa was made under the auspices of the Office of Seed and Plant Introduction and Distribution of the Bureau of Plant Industry.

Acknowledgment is here made to Captain Bussy, Chef du Bureau Arabe at El Oued, for the cordial assistance rendered by him to Mr. Kearney during the latter's stay in the Souf region.

A. F. Woods,
Pathologist and Physiologist.

Office of Vegetable Pathological
and Physiological Investigations,
Washington, D. C., August 22, 1905.

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AGRICULTURE WITHOUT IRRIGATION IN THE SAHARA DESERT.

INTRODUCTION.

In the great desert of northern Africa, stretching across in a belt from southeastern Algeria to the borders of Tripoli, is the region known as the "Erg." It is a land of enormous sand hills, some of which reach a height of 500 feet. Chain after chain of these great dunes, with knife-edge summits and steep slopes and trough-like valleys between, extend diagonally northeast and southwest across this part of the Sahara. (Pl. II, fig. 1.) It is like an ocean caught in a raging storm, with its huge billows rising skyward and held fixed and motionless. Not a leaf nor a blade of grass, not a bowlder nor a pebble mars the smoothness of the sand. Never is the least trace of water to be seen on its surface. The few drops of rain that fall at rare intervals are drunk up as soon as they touch the thirsty ground. Pure quartz sand it is, light yellow in color and so fine of grain that the least breath of air sends a little cloud of it curling off the sharp crests of the ridges. When a hard wind blows the air is filled with it, the sun is blotted out at noonday, and the traveler can hardly see his horse's head in front of him. The sharp-cornered particles of sand sting his face and blind and bewilder him. The vague tracks of camels and donkeys, the only roads through this wilderness, are quickly covered up, all landmarks disappear, and without an experienced guide one is sure to be hopelessly lost.

It is a desolate and unfriendly landscape, yet at times not without a weird beauty of its own. When the sun is high the glare is blinding and there is little to attract one in the scene. But in the early morning and the late evening the sand assumes a golden color, and the dense black shadows cast by the dunes bring out their contours in sharp relief. Then their surface is seen to be modeled by series of delicate ripple marks left by the wind, and one finds it hard to believe that when he climbs the next high ridge he will not see the ocean at his feet.

Who would suspect that amid these mountains of bare sand, where even the hardy shrubs and grasses of the desert find no foothold,[a] men can live by the products of the soil? Yet in the very heart of the Erg, two long days' ride east or west from the nearest habitations, there exists one of the most highly developed agricultural communities in the world. This is in the country known as the Oued Souf, situated in extreme southeastern Algeria (see fig. 1), about midway between the oases of southwestern Tunis and the Algerian oases known as the Oued Rirh, in which latter the date palm is grown by

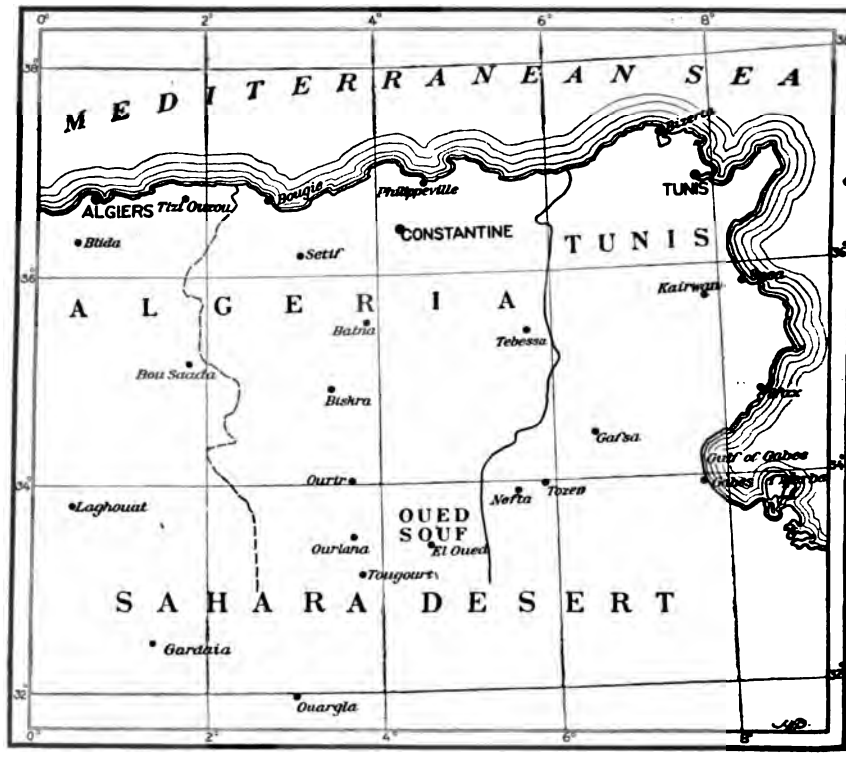

FIG. 1.—Map showing location of the Oued Souf with respect to other localities in Algeria and Tunis.

Europeans upon a commercial scale.[b] From El Oued, the capital of the Souf, it is about 70 miles southwest to Tougourt, the chief town of the Oued Rirh, and about the same distance northeast of El Oued is Nefta, the nearest oasis in Tunis. The elevation of El Oued is about 257 feet above sea level.

[a] Only eight species of flowering plants were found growing wild in the Souf region by Massart. See "Un voyage botanique au Sahara," p. 249 (1898).

[b] See Plate II (map) in Bul. 53, Bureau of Plant Industry, "The Date Palm," by W. T. Swingle.

From the tops of the lofty sand hills that surround El Oued an excellent view can be had, and there one can form a clear idea of the character of this remarkable country. (See Pl. I, frontispiece, and Pl. II, fig. 3.) Assuredly there are few regions where any sort of agriculture is carried on under more extraordinary conditions. As far as the eye can reach it rests upon an expanse of pure sand, heaved up into range after range of dunes.[a] In the hollows among these dunes are the gardens of date palms, sometimes mere pockets containing 10 or 20 trees, sometimes larger basins in which are groves of 50 to 100 palms.

Often the bordering sand hills are much higher than the tallest of the palms, so that many of the gardens can not be seen until one is on the very edge of the basin. In other places, however, the ridges are lower or gaps occur, allowing a cluster of feathery crowns to peep through. These are of such a dark green as to look almost black against the pale sand. A more striking contrast of colors could not be imagined. The trunks are rarely seen until one reaches the brink of the basin or pocket in which the palms are growing.

We have before us, in short, a network[b] of basins or hollows containing small groves of date palms and separated by great hills and ridges of sand. The aspect of the country is wholly different from the Oued Rirh in Algeria and the Djérid in Tunis, where each oasis is a dense continuous forest of date palms, containing often several hundred thousand trees,[c] and situated upon comparatively level land.

Such, then, is the country of the Souf, a land where there is practically no rainfall, where there are no streams nor springs nor flowing wells to furnish water for irrigation, where the soil is a pure hard sand devoid of organic matter and blown about in clouds by every wind, so that unceasing vigilance is needed to keep the gardens free from it, and where the summer heat is almost as great as anywhere in the world. Yet here the date palm grows to perfection, yielding fruit of better quality and in larger quantity than elsewhere in the Sahara. How this has been brought about we shall presently see in these pages; but first we should know what manner of men are they who have developed a flourishing agriculture in a land where Nature seems to frown most severely upon all efforts to win a living from the soil. The race that has succeeded so well in the face of such tremendous obstacles must needs be an interesting one.

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[a] The surface of these dunes is easily moved, even by a light breeze, but the core is said to be stationary and composed of stratified materials.

[b] The Arab word "erg" (plural areg) means "a vein."

[c] In 1899 there were only 192,000 date palms in bearing in the entire Souf region.

POPULATION.

There are about 25,000 people in the Souf region, 5,500 of whom inhabit the capital town, El Oued, and its immediate neighborhood. Several distinct tribes are included in this population, some being chiefly nomadic shepherds, and others more sedentary, devoting most of their time to the care of their gardens. They are for the most part a healthy and strong looking race, and are much more energetic than the inhabitants of other north African oases. This is doubtless partly due to the unceasing labor demanded by the conditions under which they live and partly to the fact that their climate is a healthful one, despite the intense heat of summer. There is no standing water nor even moist surface soil, and mosquitoes are said to be unknown. The dry air and the hot sand are not friendly to the germs of contagious diseases. The conditions are, therefore, very different from those in other oases of the Sahara, which are so overirrigated as to be mere swamps in summer, scourged with malarial fevers.

The inhabitants of the Souf region, who are called "Souafas," depend for a livelihood largely upon the products of their gardens, but they have other resources as well. The more nomadic tribes possess flocks of sheep and goats. They have almost a monopoly of the trade of camel drivers in a large part of the Sahara, guiding caravans eastward into Tunis, westward to Biskra, and far south into the heart of the great desert. Their camels are considered the largest and finest of the Sahara. The men of the Souf are indefatigable walkers, thinking nothing of traveling 20 or 25 miles a day through the loose sand. Their camel's-hair shoes, tightly bound around the ankles, are much better adapted to this sort of travel than the loose-fitting, heelless slippers generally worn by the Arabs.

In building their houses, as in cultivating their palms, the Souafas have many difficulties to contend with that are not experienced by the dwellers in other oases. Elsewhere in the Sahara, sun-dried brick, like the Mexican adobe, is the universal building material. But in the Oued Souf there is no clay to be had. Consequently the town of El Oued and all the villages of the region are constructed with irregular masses of grayish, crystalline, gypseous rock, cemented by plaster made from the same material, which thus furnishes both stone and mortar. Wood being very scarce, the roofs are not flat, wooden ones, but consist of rows of small, flattened cupolas, not unlike old-fashioned beehives, which give a very odd look to the cube-shaped houses. (Pl. II, fig. 2.) In its architecture, as in everything else, the Souf is unique. The immaculate cleanliness of the villages is surprising to the traveler who is familiar with the filthy streets of most Arab towns. The pure, dry sand is constantly drifting among the houses, and quickly buries all refuse.

CLIMATE.

Exact data in regard to the climate of the Oued Souf are not easily obtainable. The observations here given were made chiefly by a medical officer of the French army during the summer of 1884.[a] Unfortunately records covering a period of several years are not available.[b]

The summer temperatures are very high, few hotter localities being known in the Sahara. The monthly maximum shade temperatures observed by Escard in the summer of 1884 are as follows (in degrees Fahrenheit):

April	93	August	116.5
May	100	September	113
June	106	October	91.5
July	122		

In June, 1904, a maximum of 127.5° F. is said to have been reached. The sum total of temperature during the summer, a factor of the greatest importance in the ripening of the finer varieties of dates, is said to be greater in the Oued Souf than in the Oued Rirh and the Djérid. At the time of the writer's visit (November 22–26, 1904) cool, cloudy weather prevailed, and the nights were decidedly cold.

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[a] Escard, Etude médicale et climatologique sur le pays de l'Oued Souf. Archives de Méd. et de Pharm. Milit., 7: 33 (1886).

[b] Since the above chapter on climate was written the records of observations made at El Oued during the whole of 1904 and parts of 1903 and 1905 have been received, through the courtesy of the Director of the Meteorological Service of Algeria. These observations necessitate some modifications in the previously written discussion of the climate of the Souf. The absolute maximum temperature at El Oued in 1904 was 121.8° F. in May instead of 127.5° F. in June. The absolute minimum in 1904 was 32° F. The mean relative humidity during 1904 at El Oued was 58.8, which is lower than the normal at Tozer, in Tunis (60.8), but higher than the normal at Ouargla and Biskra, Algeria (47.2 and 48.4, respectively), and at Yuma, Ariz. (42.9). The sum of the monthly means of evaporation at El Oued in 1904 is 156 inches, while the normal at Tozer is 94 to 98.5 inches. The total precipitation at El Oued in 1904 was 3.23 inches, while the normal yearly total is 3.61 inches at Ouargla, 6.73 inches at Biskra, 5.1 inches at Tozer, and 2.83 inches at Yuma.

The observations on the prevailing direction of the wind during 1904 and the first half of 1905 do not agree with those made by Escard and quoted in the text, but the data are insufficient for an adequate discussion of this factor.

As the climatic factor which is most important in date growing is probably the effective temperature during the ripening season, a calculation has been made of the sum totals of daily mean and of daily maximum temperatures above 64.4° F. (18° C.) during the months of May to October, 1904, at El Oued, and, for the sake of comparison, of the sums for the same months of the same year at Ouargla and Biskra, Algeria; Tozer, in Tunis, and Mecca, in the Salton Basin, California. Records at Mecca for May and June, 1904, not being available, the records for those months at Imperial, Cal., were substituted in making

Almost every winter freezing temperatures are reached, although probably the minima are higher and frosts are less frequent in the Oued Souf than at Tougourt and at Tozer. In the winter of 1903–4 the absolute minimum was 32° F., and for several preceding winters 27° F.

In respect to atmospheric humidity, the absence of surface water probably tends to keep the air drier than is generally the case in the oases of the Sahara.

The rainfall is said to be even less than in the Oued Rirh, where the average yearly precipitation (at Tougourt) is only 5.3 inches. Most of the rain is divided between two periods—October to November, and February to March. The rains are generally torrential in character and fall during several successive days, with intervals of sunshine.

The sky is nearly always clear in summer. Toward the end of August light clouds appear in the morning and evening, but no rain falls until October. During the writer's four days' visit to the Souf

the calculations for Mecca, experience having shown that the temperatures recorded at Mecca and at Imperial are very nearly identical.

TABLE I.—*Sum of daily mean temperatures above 64.4° F. (18° C.) from May 1 to October 31, 1904.*

Locality.	Degrees Fahrenheit.	Degrees centigrade.
El Oued, Algeria	3,672.6	2,040.3
Ouargla, Algeria	3,961.3	2,200.7
Biskra, Algeria	3,140.4	1,744.6
Tozer, Tunis	3,831.3	2,128.5
Mecca, Cal	3,591.5	1,995.3

The sum of daily means at Biskra for 1904 is nearly 200° F. lower than the normal, as based upon observations covering a period of 10 years (see W. T. Swingle, Bul. No. 53, Bureau of Plant Industry, p. 66), and the sum at Mecca for that year is about 400° F. lower than the normal for Indio, Cal., a few miles distant.

TABLE II.—*Sum of daily maximum temperatures above 64.4° F. (18° C.) from May 1 to October 31, 1904.*

Locality.	Degrees Fahrenheit.	Degrees centigrade.
El Oued, Algeria	6,325.7	3,514.3
Ouargla, Algeria	6,501.6	3,612.0
Biskra, Algeria	5,219.1	2,899.5
Tozer, Tunis	5,903.6	3,279.8
Mecca, Cal	6,370.1	3,539.0

In calculating the sums of daily maximum temperatures allowance was made for mean monthly minima falling below 64.4° F., in accordance with the practice suggested by Swingle (ibid., p. 67). The sum of daily maximum temperatures at Biskra during May to October, 1904, is about 250° F. lower than the normal for 12 years (Swingle, ibid., p. 68). The sum for Mecca is about 700° F. lower than that for Imperial, Cal., in 1902.

at the end of November the sky was overcast about half of the time, and there were occasional gusts of cold, drizzling rain.

Winds are probably more frequent and more violent in the Oued Souf than in the other groups of oases mentioned. It would appear, in fact, that windiness is the ordinary condition there. During the winter, northwest and northeast winds prevail. From April to October, however, the wind is generally from the south (the sirocco) or the southeast (the simoom). The sirocco is the hottest wind, but is less frequent than the simoom, which is generally more violent and transports more sand. All these are winds that blow more or less steadily for several hours and often days at a time. Cyclonic sand storms also occur, arising suddenly and lasting but a short time. Such storms are never accompanied by rain.

Owing to the lack of natural vegetation (see Pl. II), and the fineness of the sand with which the country is covered, strong winds carry with them a great deal of material, so that the face of the land is being constantly altered. This is shown by the fact that an apparently fresh wagon track noticed by the writer on his journey from Nefta was completely buried in many places by large heaps of sand. During his four days' stay in the Souf country, a strong wind blew constantly, often making travel difficult, as the particles of sand stung the face and made it hard at times to keep the eyes open. The air was frequently so full of sand that one could see but a few rods ahead.

The slopes of the dunes that border the gardens are very steep, so that when a heavy wind is blowing much sand rolls down upon the floor of the garden. Generally there is a fence or palisade along the crest of the dunes, made by sticking palm leaves or pieces of gypsum rock close together (Pl. II, fig. 3; Pl. III, fig. 1; Pl. IV, fig. 1), but this only partly arrests the blowing and drifting sand, and it is necessary to remove it frequently from the gardens. The task is a laborious one, as the sand must be carried up the steep hillside in baskets and dumped on the outer slope of the dunes. But if it were neglected, in a few years the trees would be buried, especially in smaller gardens. The writer saw several little gardens that had been abandoned by their owners where the basin was almost filled and only the crowns and a small part of the trunks of the trees still projected above the soil.

Another injurious effect of the sand-carrying winds is that when harvested the dates always have more or less sand adhering to the skin, and this must be brushed or washed off before they are fit for export. Dates that had been kept for some weeks in the houses of natives, and even those freshly gathered from the trees, were very unpalatable to the writer on this account; although the Souafas themselves do not seem to mind eating a good deal of sand with their dates.

WATER SUPPLY.

There is no surface water in the whole Souf country, excepting possibly, a small sebka, or salt pond, of which the writer was told but which he did not see. There are no natural springs, although ground water is everywhere very near the surface in the hollows among the dunes. It is said to occur sometimes in strata of pure quartz sand, sometimes in gypseous sand. The distance to standing water is said to reach as much as 40 feet in different parts of the region, although averaging considerably less; but in the bottoms of the basins in which date palms are grown it is encountered often at a depth of only 2 or 3 feet below the surface of the soil, thanks to the extensive excavation that has been done. In one garden, near the town of El Oued, the writer saw water standing at a depth of 6 feet in a large hole that had been dug to receive manure. The Souf oases are believed to mark the course of a buried Quaternary stream; Oued Souf means "murmuring river."[a]

As we shall presently see, the date palm is not irrigated in the Souf country, receiving at most a few waterings by hand during the first summer after planting. In almost all the gardens, however, shallow wells occur,[b] the water of which is used for household purposes and for irrigating small plats of garden vegetables. (Pl. III, fig. 3.) These are generally situated on the slope of the bordering dunes, 10 feet or less above the bottom of the basin, and water stands in them at a depth of 10 to 16 feet. In the town of El Oued the wells are much deeper than in the gardens, water standing in them at 30 to 40 feet. All this water is under a slight pressure, rising in the wells about 1.5 feet higher than the general water table. Small gardens of vegetables and tobacco,[c] irrigated from deeper wells, are also located in some parts of the region far above the bottoms of the basins. Practically no grain is raised, wheat and barley being brought by caravan from other parts of Algeria and from Tunis, to be exchanged for dates.

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[a] It is difficult to obtain a very satisfactory idea as to the distribution of the ground water in the Souf region, its depth at various points, and the amount of excavation necessary to enable the roots of the palms to reach it easily. The natives themselves give the most conflicting answers to questions upon this subject, and there are serious discrepancies in the accounts that have been published by French authorities upon irrigation. The whole matter evidently needs to be carefully studied by competent hydrographers, a study which is certainly warranted by the rarity of this type of agriculture.

[b] In 1883 Rolland estimated that there were 4,431 wells in the Souf region.

[c] Tobacco growing, which is unrestricted in Algeria, is a profitable industry in the Souf country on account of that region's nearness to the frontier of Tunis, where the growing of this crop is forbidden by law and where the selling of tobacco is controlled by the government. Agents of the Tunisian tobacco monopoly frequently visit the Oued Souf to purchase supplies.

The plats of vegetables that are irrigated from wells in the date gardens are situated on terraces constructed in the side of the sand hills, usually 10 feet or less above the floor of the basin. (Pl. III, figs. 1 and 3.) The well water is raised by hand in a shallow bucket, generally made of basketware covered outside with pitch, but sometimes of goatskin, which is hung on the small end of a slender palm trunk and counterpoised by a piece of rock fastened to the large end. The pole is fastened by its center to a crosspiece that is supported by two vertical posts made of stouter palm logs or of cemented rock. The bucket is emptied into a little cement basin adjoining the well curb, whence the water flows through a system of small conduits into the plats that are to be irrigated. Flood irrigation alone is practiced. As there is no soil in the region from which ditch banks and ridges that will stand up when wet can be made, the conduits and ridges of the plats, as well as the lining and curb of the well, are made of the same dark-gray plaster with which the walls of the houses are cemented. Plugs of wool are used for stopping the conduits at places where water is to be diverted into the plats. Among the vegetables most commonly grown are cabbages, turnips, radishes, carrots, pumpkins, melons, watermelons, onions, tomatoes (a small-fruited sort), and peppers.

In parts of the Souf region, especially east of the capital town, El Oued, the water of the wells is said often to contain enough magnesium and other salts to make it disagreeable for drinking.[a] West of the town, on the other hand, the water is said to be generally very pure. The difference is thought to be sufficiently great to have a marked effect upon the quality of the dates, the most renowned Deglet Noors of the Souf region being produced near the village of El Amiche, where the water is purest. The peculiar character of the water supply of the Oued Souf is not without advantages. Eminent authorities are of the opinion that the underground sheet is abundant and that it is much less liable to exhaustion than in the Oued Rirh, where numerous flowing artesian wells exist.

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[a] Well water in the Souf, according to an analysis cited by Jus (Les oasis du Souf du Département de Constantine, Bul. Acad. d'Hippone, No. 22, p. 67 (1886), has the following contents of solid matter in grams per liter of water:

Sulphates	1.9993
Chlorids	.7769
Carbonates	.2999
Nitrates and dissolved organic matter	.0690
Silicates, etc., in suspension	.0335
Total	3.1786

Schirmer (Le Sahara, p. 261) states that the mean sult content of well water at El Oued is 2.77 grams per liter.

SOILS.

The soil of the whole Oued Souf region is a fine-grained, light-yellow quartz sand, which is practically uniform in character to a considerable depth.[a] Here and there beds of a coarse, rather soft, gypseous rock occur at a depth, it is said, of 10 to 20 feet and in strata 1.5 to 10 feet thick. The crystals of which this rock is composed are very large, often 1 foot long. They are often aggregated into masses which, on account of their shape, are known as "Souf roses."[b] It is therefore a fair inference that the Souf soils are sufficiently rich in lime. They are very poor in organic matter and doubtless in nitrogen. Other data as to their composition are wanting.

In the eastern part of the region the soil of all the gardens is said to be somewhat saline, and the writer was told that there is even a small sebka (salt pond) in that section, although he saw nothing of these conditions. There is said to be nowhere enough salt to injure seriously the palms themselves, but the yields of fruit are diminished by this cause, and the dates are somewhat smaller and of slightly inferior quality. Consequently, palms in full bearing in the gardens west of El Oued are worth from two to ten times as much as those in the gardens east of that town. The Souafas do not pretend to distinguish some varieties of the date palm as being more resistant to salt than others, as do the inhabitants of the Djérid oases, where the salinity of the soil is often very pronounced. Neither have they adopted any special methods of preparing and handling salt land by drainage, flooding, or otherwise, as is the case in the Tunisian oases. It is fortunate for the Souafas that their soils are not saline, or but very slightly so, as it is hard to see how they could possibly reclaim strongly saline lands in view of the conditions of water supply in their country.

THE DATE GARDENS.

Let us now have a closer look at the gardens. (Pl. III, figs. 1 and 2.) The craterlike basins which they occupy are generally circular or nearly so, and from 35 to 50 feet deep. The bottom is entirely given up to the palms. Descending to the floor of the basin,

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[a] According to Jus this hard quartz sand extends to a depth of 3.5 to 4.5 feet; next there are from 7 to 8.5 feet of a "reddish gypseous sand;" and then 3 to 3.5 feet of either "a fine quartz sand" or "a yellow gypseous sand."

[b] The composition of this rock, as given by Jus (ibid., p. 69), is:

	Per cent.
Quartz sand	37.00
Clay	5.10
Gypsum	41.40
Carbonate of lime	3.20
Carbonate of magnesia	1.50
Water	11.43

or "ghitan," as the natives term it, we find it to be a practically level expanse of clean, bare sand, checkered with the bright sunlight and the singularly black shadows that are cast by the trunks and leaves. (Pl. V, fig. 1.) The palms stand farther apart than in the gardens owned by natives in the Djérid and the Oued Rirh, but are not planted in rows and at equal intervals, as in the French plantations in the latter region. While native gardens elsewhere in the Sahara are a perfect jungle of various fruit trees, besides garden vegetables, barley, and alfalfa underneath the palms, in the Oued Souf one sees only scattered pomegranate and fig trees, and the groves have an unfamiliarly open and bare look. While in other oases the soil is often rich and black and is almost always moist, here it is quite dry on the surface. One misses, too, the irrigation and drainage ditches by which the gardens of the Djérid and the Oued Rirh are cut up into small plats.

Another feature of the Souf date orchards that immediately attracts attention is the enormous thickness of the trunks of the trees. They sometimes attain 3 feet in diameter. (Pl. V, fig. 2.) This is probably due to the trees being comparatively far apart, thus receiving plenty of light and air from every side, and is, perhaps, also to some extent a reaction to the buffeting of the sand-laden winds. At any rate, it is a useful character, giving the trees power to withstand the winds that prevail here to a greater extent than in the other oases of the northern Sahara. The relatively small height of the palms, which rarely exceed 30 feet in the Oued Souf, gives them a further advantage in this respect. Frequently, when the base of the trunk has become weakened and there is danger of the tree blowing down, the natives make a "dokana," or low, circular mound of soil, plastered on the outside, to strengthen it. (See Pl. V, fig. 1.)

The palms are almost invariably strong and healthy looking. The foliage is extraordinarily well developed, and the leaves commonly measure 15 to 20 feet long. The yields of fruit, as stated by the natives, are very heavy.

So unusual are the conditions under which date palms are grown in the Souf country that further details as to the methods used by the natives can not fail to be interesting.

PLANTING.

As the date palm is a tree that requires a great deal of water, it can evidently be grown in a dry country without surface irrigation only in places where its roots can quickly make their way to ground water. This is exactly the condition obtaining in the Oued Souf, where the palms are artificially watered only during the first summer after the offshoots are planted, and are then left to shift for themselves, so far as water supply is concerned.

As we have seen, the bottoms of the basins where the palms are grown are not only far below the summits of the surrounding sand hills, the height of which is increased by the sand removed in excavating the gardens, but are even considerably lower than the mean surface of the country. It is said that in starting a new garden the practice is first to sink a well in the bottom of the basin in order to find out the depth at which water stands. The floor of the basin is then scooped out until it is so near ground water that when a hole 1½ to 4 feet deep is made to receive the young palm its roots will have to descend only about 1 or 1½ feet to reach standing water. It is said that to attain the desired depth it is generally necessary to remove 10 to 20 feet of sand.

The date palm is always artificially planted in the Oued Souf, never springing up spontaneously from seed, as in other oases. It is never planted elsewhere than on the floor of the basins among the dunes, or at most a very few feet above the bottom. These basins are probably in all cases natural depressions, but are artificially deepened to facilitate the roots reaching ground water. New gardens are frequently started in unoccupied basins, and old ones belonging to enterprising owners are being constantly extended by cutting down the slopes of the bordering sand hills and planting a few palms every year or so. (See Pl. III, fig. 2.) The larger and better-situated basins are now all occupied by gardens, and for the newest plantations it is often necessary to use small, shallow depressions, where there is frequently room for but half a dozen trees. Sometimes the slope is not cut down quite to the level of the older part of the garden, the new palms being set out slightly above the level, on a terrace made in the side of the sand hills. (Pl. IV, fig. 1.) When planted on the slope or near the foot of it, sections of palm log or a number of palm leaves are placed on the uphill edge of the hole to check the drifting of sand into it.

Owing to the scarcity of offshoots in the Souf region, the work of extending the gardens does not proceed as rapidly as the energetic population could wish. The French attribute the nonproduction of offshoots in the Souf to the fact that the palms are so valuable there that it does not pay to let the offshoots develop, absorbing a part of the energy that would otherwise go to fruit production. They believe that the Souafas find it actually cheaper to send to the Oued Rirh for suckers, paying 40 to 60 cents apiece for them in addition to the cost of transportation, than to let them grow on their own trees. Economic considerations aside, however, it is probable that the date palm does not sucker as freely in the Oued Souf as in other oases, because of the dry condition of the surface soil, never wet by irrigation, and because the blowing sand tends to bury the young offshoots and to lacerate their tender buds. The natives, when questioned

about the comparative rarity of offshoots at the base of their palms, reply simply that it is due to the absence of irrigation, without going into details. Whatever may be the cause of the deficiency, there is a great demand for offshoots, and to supply this demand caravans are sent to procure suckers, especially of the Deglet Noor variety, to Tougourt, or even as far as Ouargla, 135 miles away. In those oases they are produced more freely, the palms being irrigated.

Offshoots for planting are generally taken from the mother palm about the end of February. The natives say that they could be planted even earlier, but in that case the parent tree is likely to suffer from the access of cold air to the wound made in cutting off the sucker. In case the offshoots are removed in midwinter, their bases are slightly charred before planting, and this is thought to protect them from the cold.

The hole made to receive the young palm is sometimes as much as 6 feet in diameter, but probably in most cases less. Its depth, as we have seen, depends largely upon the distance to ground water, being generally 1½ to 3 feet in the bottom of the gardens near the town of El Oued. A young palm was seen near El Oued that had been set out near a well about 6 feet above the bottom of a garden, in a hole 3½ feet deep. (See Pl. IV, fig. 1.)

The palms are not set out in straight lines. They stand much farther apart than in gardens belonging to natives in other oases, 20 feet being the average distance. This wide planting is probably necessitated by the poverty of the soil, which is practically a pure sand, while the almost entire absence of subsidiary cultures makes the shade afforded by close planting less valuable than in other oases.

It is estimated that the planting and care of a young Deglet Noor palm up to the time it begins to yield costs $25 in the Oued Souf, as against $5 to $10 in the Djérid oases of Tunis.

CARE OF PALMS.

During the first summer after it is planted the palm may receive a few irrigations by hand with water from the well that is situated on the hillside in nearly every garden, although it is said that frequently no irrigation whatever is given. While still very small, before the leaves have grown out enough to project far above the mouth of the hole in which it is planted, the tree is protected from drought and from the cold of winter by covering the hole with palm leaves, dead pumpkin vines, etc.

When the palms are manured the sand that has piled up into a low mound around the base of the tree is removed and the soil beneath is thoroughly worked. This is apparently the only cultivation the trees receive.

FIGHTING THE SAND.

While elsewhere in the Sahara irrigation entails the heaviest labor connected with palm culture, in the Oued Souf it is the struggle that must be waged with the constantly encroaching sand that demands the tireless efforts of the gardeners. Every strong wind carries great volumes of sand. The slight fences of palm leaves and the low walls of gypseous rock that are constructed along the crests of the bordering dunes are only a partial protection against this invasion. Once over these weak barriers, the sand rolls down the steep slopes almost like water. The danger is always present, but is most pressing when the dates are ripening. Then bunches of fruit that hang close to the ground can be half buried by a few hours of high wind, and only the most strenuous efforts can save them. If a second storm occurs before the bulk of the sand is removed, the crop is hopelessly lost.

The work of cleaning out the basins is very laborious, being done, like the original excavation, almost entirely by hand. Travelers in this region have compared this work to the activities of ants, rather than of men. Laborers shovel the sand into baskets and carry them in a ceaseless procession to the top of the slope, their feet sinking deep into the flowing sand at every step. After a heavy sand storm the work must be continued from dawn to dark. In summer, during the blazing midday hours, the heat is too great for such heavy labor, and the removal of the sand goes on at night and in the early morning hours. At times a large part of the population of the region is engaged in this heavy task. It is paid for at the rate of 1 cent for every 5 baskets of sand, and the laborer has, in addition, the privilege of eating as many dates as he desires in the garden in which he is working. Only rich proprietors use the sturdy little gray donkeys of the Souf for transporting the sand from their gardens.

MANURING.

The soil of the Oued Souf is practically nothing but pure sand, containing even in the older palm gardens very little organic matter. Manuring is consequently essential not only to the production of good yields but even to the well-being of the palm itself.[a]

It is not uncommon in the Souf country to see palms that have thick trunks up to a certain point, above which they contract more or less abruptly to a much smaller diameter. In many cases, at a still greater height, the trunk again becomes thicker. This state of things is explained by the natives as due to a partial starvation of the tree at

[a] For that matter, manuring is generally practiced by good farmers in the oases of the Oued Rirh and the Djérid, although there the growing of leguminous food and forage crops (broad beans and alfalfa) helps to restore to the soil the nitrogen that is taken up by the palms.

the time when the trunk began to diminish in size. If manure is subsequently supplied to it, the palm is soon able to return to its normal rate of growth and the trunk again becomes larger.

Palms are not manured until they are 10 or 12 years old. At that age each tree usually receives 10 sacks (5 camel loads) of manure, half of which is applied on one side of the trunk the first year and the other half on the other side the following year. Thereafter, in order to obtain the highest yields, the trees should be manured every twelve or fifteen years, although sometimes thirty years are allowed to elapse between two manurings. Older palms receive as much as 14 sacks of manure (7 at each application). Camels' dung (see Pl. IV, fig. 2) only is used for date palms in the Oued Souf, although in the oases of Tunis that of donkeys is preferred, the natives there considering camel manure injurious where irrigation is practiced. The cost of a sackful of camel manure in the Oued Souf was stated by one informant to be 25 to 30 cents, while another placed it at 40 to 45 cents. In either case it is evidently an expensive article.

Manure is never used until it is thoroughly rotted, and even then it is not allowed to come into direct contact with the base of the tree. It is placed in a hole that is dug to a depth of 3 to 6 feet below the general level of the floor of the basin and at a distance of 5 or 6 feet from the foot of the palm. When several neighboring palms are to be manured at the same time, the hole is dug in the center of the space among them, and is made so large that none of the palms is more than 6 feet distant from its edge.[a] The hole is then filled with a mixture of one part manure and one part of a bright yellow sand called "baker," which is somewhat more loamy and probably contains more gypsum than the surface sand of the region, and is obtained at a greater depth. Unmixed manure is never used, even though thoroughly rotted, being considered injurious to the palm roots. The soil removed in digging the hole is never put back, being "dirty," as the natives express it.

October is considered the best season for applying manure, although March is also a good time. Unskillful growers sometimes manure their palms at other seasons, but this is thought to do more harm than good. Sometimes, unless the hole is opened and the manure removed as soon as the tree shows signs of injury, it is said to die from the effects of manuring at the wrong period.

The effect of manuring upon the yield is large and almost immediate. It is said that a tree which bears 200 pounds of dates one year will often give 400 pounds the season following if meanwhile manure

[a] One such hole, freshly excavated at the time of the writer's visit, occupied much the greater part of the area among four palms, being 12 feet long and 5 feet wide. It was divided unequally by a narrow ridge of soil left in place. The object of this division could not be learned.

has been applied. No distinction between varieties is made in the Oued Souf in manuring, nor, so far as could be ascertained, in regard to other cultural practices.

HARVEST.

At the time of the writer's visit (November 22–26, 1904) the date harvest had been completed in all the gardens of the Souf country. The Deglet Noor harvest is said generally to begin about October 25. In the Tunisian oases, on the other hand, the harvest of Deglet Noor and Fteemy dates—the two most important varieties—was at its height in November, and continued throughout December and even the earlier part of January. Of course, in the latter case many of the dates were ripe long before they were gathered, and the long duration of the harvest was largely due to the relative scarcity of the expert labor required, the crop being many times as large as in the Souf. Yet it seems certain that in the Oued Souf, dates, especially the Deglet Noor variety, ripen earlier than in the Oued Rirh oases of Algeria or the Djérid oases of Tunis. This would be expected from the fact that the summer is drier and likewise hotter in the Oued Souf than in the oases of the Djérid. Furthermore, the situation of the gardens, in hollows bordered by hills of light-colored sand that are generally higher than the tallest palms, is favorable to an early ripening of the dates, as they must receive a great amount of additional heat by reflection from the soil. More perfect natural conditions for forcing fruit to early maturity could probably not be found in the world.[a]

This greater heat and dryness of the Souf climate affect the fruit in other ways than merely by hastening its ripening. The dates produced are reputed to be the best grown in the Sahara. They seem, as a matter of fact, to be sweeter and at the same time drier and more solid than in the Djérid. This is especially true of the Deglet Noor, which is of decidedly firmer texture, containing less water. The Souf dates are said to keep better and to be more adapted to export than those of the other oases, showing less tendency to blacken and become moldy.

It was a matter of regret to the writer that the harvest was not witnessed in the Souf, although it could not be learned that the methods followed there differ from those practiced in other oases. So far

[a] Rolland (Hydrologie du Sahara Algérien, Paris, 1894, p. 222) describes the basins as "a sort of fiery furnace, under the influence of solar radiation. The dates here attain perfect maturity. Here are realized, better than anywhere else in the Sahara, the conditions assigned by the Arab proverb to the prosperity of the palm and the excellence of its fruits: 'Its feet in the water and its head in the fire of heaven.'"

as is known, the pollination of the female flower clusters in the spring is also effected in the same way as in the Oued Rirh.[a]

YIELDS.

It was impossible to secure very reliable statements of yields from the natives, but from all that could be learned these must be unusually large in the Souf country. The clusters of the Deglet Noor are said frequently to weigh over 55 pounds each, and to attain sometimes 90 pounds. Single trees of this variety, which is one of the lightest bearing kinds, sometimes yield as much as 330 pounds in the Oued Souf. It was estimated in 1883 that the date crop from the 175,000 palms (of all varieties) in full bearing then existing in the Souf region was 7,000,000 pounds. This would mean an average yield of 40 pounds per tree, as against an average yield of 28 pounds estimated to have been produced in the Oued Rirh the same year.[b] A good palm in full bearing is valued at from $50 to $130, according to the variety to which it belongs.

The practice of planting the trees farther apart than in other oases is perhaps one reason for the large yields. By wide planting, not only do the roots of each palm have a larger feeding area, but the trees do not shade each other so much and more of the fruit can develop and ripen. Moreover, the climatic and topographical conditions, as we have seen, are exceptionally favorable to the ripening of dates.

VARIETIES CHIEFLY GROWN.

As has already been indicated in this paper, date palms in the Oued Souf rarely, if ever, spring up from seed, as they do in other oases where the conditions are more favorable to the spontaneous development of the palm. They are propagated only by offshoots that are taken from the parent tree and planted by the grower. Consequently we do not see a multitude of seedlings, generally of very inferior quality and of almost endless diversity of characters, filling every waste corner and roadside and even crowding out good trees in gardens that are not well cared for. Practically every palm grown in the Souf belongs to some well-known and well-liked variety.

The number of varieties found in this region is considerable. Most of the gardens contain a mixture of several kinds, although in some of the recently created ones the tendency is to plant only one

[a] Described in Bul. 53, Bureau of Plant Industry, "The Date Palm," by W. T. Swingle, 1904, pp. 26–29.

[b] These estimates are quoted from Rolland (ibid., p. 324). The overwhelming importance of the date crop in the Souf region is shown by the fact that the same author states the value of the 1883 crop of dates to have been $301,730, while that of all other crops combined was only $20,900 in that year.

sort, most often the Deglet Noor. Nearly all the popular varieties of the Souf are also common in the Oued Rirh.[a]

On the other hand, some of the most characteristic Souf types are very rare in the Djérid oases of Tunis, only 70 miles away. Such individuals as occur there are mostly grown from offshoots that have been brought directly from the Souf. The principal variety common to the two regions is the Deglet Noor, which is now abundant in Tunis, but is said to have been first introduced into that country from Algeria about two hundred and fifty years ago. The Souafas still go to the Oued Rirh oases to procure offshoots, and they very likely brought thence those with which the first gardens were started among the sand hills of the Souf.

The most important of the numerous varieties of the Souf, in point of abundance as well as of quality, are, in about the order named: Deglet Noor, Rhars, Tafazween, Massowa, Deglet Beida, and Takermest. Of these Rhars is the earliest and Deglet Noor the latest to ripen. After the Deglet Noor, Tafazween is the best sort that is widely grown. It is a large, reddish-bay-colored, translucent date, very sweet and rich in flavor.[b] A highly esteemed but very rare variety is the Fezzani, which is said to be superior even to the Deglet Noor when dried, and to keep well for two years. Rhars, a variety that is celebrated for its heavy yields, is extensively planted.

In the Oued Souf, as in other oases of Algeria and Tunis, the Deglet Noor is the only variety that has any importance as an article of export to Europe. It is consequently the most valuable, the more so because the natives themselves generally esteem it above all others. Deglet Noor dates are carried from the Souf by caravan to Biskra, whence they are shipped by railway to the seaports. Souf Deglets are said to be about the earliest to reach the Biskra market. Their good keeping and shipping qualities have already been discussed as probably due to the peculiar climatic conditions, which give them an advantage over dates from oases where the palms are lavishly irrigated and the air is moister. On the other hand, they appear to be smaller than those in the Djérid and to be inferior in color and general appearance. The latter disadvantage is very likely due in great part to the sand-laden winds to which they are exposed. The Deglet Noor palm is said to be hardier in the Souf region than elsewhere, showing greater resistance to disease and to unfavorable climatic conditions. The foliage of the date palm appears to be less subject to the attacks of scale insects than in other oases, which is perhaps attributable to the extreme dryness of the atmosphere.

[a] Exceptions are said to be the Fezzani, Massowa, Ali Rashid, and Guettara varieties.

[b] Twenty offshoots of this variety were obtained from the Oued Souf for trial in the United States through the kindness of the French commandant at El Oued, Captain Bussy.

CONCLUSION.

The type of agriculture practiced in the Oued Souf is not dry-land farming, for it depends upon the ground water, which in the gardens is everywhere near the surface of the soil. It affords us, however, an excellent object lesson of what can be done under the most adverse natural conditions in producing a valuable crop, for throughout northern Africa the Oued Souf is renowned for the large yields of its date orchards and the high quality of their fruit.

It may be that nowhere in the United States are the conditions with respect to ground water such as to allow of a close imitation of agricultural methods used in the Souf country. One lesson is, however, to be drawn from them. The sand hills concentrate and reflect so much heat that the hollows among them are veritable forcing houses, where dates ripen considerably earlier than elsewhere. Have we not here a hint of what may be done in the Salton Basin and perhaps in other hot, arid regions in the Southwest where large sand dunes exist, and where artesian or other sources of water supply for irrigation are available? It seems certain that in pockets of this character excavated among the dunes the Deglet Noor and other valuable varieties of dates could be forced to early maturity.

Dates ripened in this way a few weeks ahead of the bulk of the crop would command a fancy price, especially as the quality of the fruit produced under these conditions would in all probability be exceptionally fine. Nor are the possibilities limited to the date palm. Other fruits, such as figs, pomegranates, and grapes, could perhaps thus be put upon the market in advance of those from any other locality in the United States. The experiment is certainly worth trying. The American fruit grower, awake as he is to every new idea, may find something worthy of imitation in the example of these sturdy inhabitants of a remote corner of the Sahara.

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PLATES.

DESCRIPTION OF PLATES.

PLATE I. (*Frontispiece.*) General view of the Oued Souf region from the town of El Oued, showing sand dunes and sunken gardens of date palms.

PLATE II. Fig. 1.—High sand dunes east of El Oued. The group is standing on a ridge separated by a ravine from the very high dune in the background. Fig. 2.—A typical dwelling house of the Oued Souf, showing its cubical form and roof composed of flattened cupolas. Fig. 3.—General view of the Oued Souf region, showing sunken date gardens and sand dunes. Fence of dead palm leaves along crest of dune in foreground.

PLATE III. Fig. 1.—Near view of sunken palm garden and surrounding dunes. Vegetable garden in left foreground, showing small size of checks. Near it a young palm, planted in a hole. Fig. 2.—Gradual extension of a palm garden by cutting down bordering sand hills. Oldest palms in background, youngest in foreground. Fig. 3.—Vegetable garden irrigated by well near bottom of basin in which date palms are grown.

PLATE IV. Fig. 1.—Hole on slope of dune near bottom of basin in which a young palm is planted. Fig. 2.—Camel manure ready for application in a date garden.

PLATE V. Fig. 1.—"Dokana," or mound of earth and plaster for strengthening the base of a palm. Shows also distance between trees, absence of other cultures, and play of light and shadow on floor of basin. Fig. 2.—Rhars palm, showing thickness of trunk.

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FIG. 1.—HIGH SAND DUNES EAST OF EL OUED.

FIG. 2.—A TYPICAL DWELLING HOUSE OF THE OUED SOUF, SHOWING ITS CUBICAL FORM AND ROOF COMPOSED OF FLATTENED CUPOLAS.

FIG. 3.—GENERAL VIEW OF THE OUED SOUF REGION, SHOWING SUNKEN DATE GARDENS AND SAND DUNES.

FIG. 1.—NEAR VIEW OF SUNKEN PALM GARDEN AND SURROUNDING DUNES.

FIG. 2.—GRADUAL EXTENSION OF A PALM GARDEN BY CUTTING DOWN BORDERING SAND HILLS.

FIG. 3.—VEGETABLE GARDEN IRRIGATED BY WELL NEAR BOTTOM OF BASIN IN WHICH DATE PALMS ARE GROWN.

FIG. 1.—HOLE ON SLOPE OF DUNE NEAR BOTTOM OF BASIN IN WHICH A YOUNG PALM IS PLANTED.

FIG. 2.—CAMEL MANURE READY FOR APPLICATION IN A DATE GARDEN.

FIG. 1.—"DOKANA," OR MOUND OF EARTH AND PLASTER FOR STRENGTHENING THE BASE OF A PALM.

FIG. 2.—RHARB PALM, SHOWING THICKNESS OF TRUNK.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 87.

B. T. GALLOWAY, *Chief of Bureau.*

DISEASE RESISTANCE OF POTATOES.

BY

L. R. JONES,

BOTANIST OF THE VERMONT AGRICULTURAL EXPERIMENT STATION AND COLLABORATOR OF THE BUREAU OF PLANT INDUSTRY.

VEGETABLE PATHOLOGICAL AND PHYSIOLOGICAL INVESTIGATIONS.

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PREFACE.

The potato is one of the most important food crops of the United States. It is, moreover, one which is subject to a number of serious plant diseases. Some of these, notably the late-blight, can be controlled by spraying. Yet this remedy is not applied by all farmers, and the annual loss amounts to many millions of dollars. Other diseases, like dry-rot and the bacterial blight, are not controlled by spraying and require a different line of treatment. The subject of disease resistance in plants has received increased attention of late, and it is likely that the introduction of disease-resistant varieties of potatoes, by supplementing spraying and special cultural practices, will be of great practical value in lessening the waste caused by disease. Although but little has been done in the United States toward securing varieties resistant to disease, the attention of potato specialists in other countries has already been directed toward this aim.

As a preliminary step in our work, Dr. L. R. Jones, botanist of the Vermont Agricultural Experiment Station, was commissioned to inquire into the occurrence of potato diseases abroad and the methods employed for their control, particularly with reference to the production of disease-resistant varieties. Doctor Jones spent six months—from April to September, 1904—in this work.

In the course of Doctor Jones's European itinerary, information of more or less value was secured at the following places, successively, and this was supplemented by a considerable correspondence covering a somewhat wider area: Marseille, Naples, Florence, Munich, Halle, Berlin and vicinity, Dresden and vicinity, Bonn and vicinity, Wageningen (Holland), Amsterdam and vicinity, Groningen, Delft, Gembloux (Belgium), Paris and vicinity, London and vicinity, Reading, Cambridge, and Edinburgh and vicinity. The thanks of the Department are accorded to the various officials and other botanists in the countries visited, whose uniform courtesies made possible the success of the mission.

As shown in this report, a considerable number of varieties are reputed to be disease resistant. The best of these were selected by Doctor Jones, and limited quantities of seed tubers were imported by the Office of Seed and Plant Introduction and Distribution of the

Bureau of Plant Industry. These are now being tested in trials co ducted in cooperation by the Bureau of Plant Industry and the Sta experiment stations in Vermont, Florida, Colorado, and Oregon, a by the Bureau at the Arlington Experimental Farm, near Washin ton. In order fully to acclimatize the foreign varieties, these tri will be continued for three years before a final report is made on the adaptation to American conditions. This test, together with t review of our present knowledge contained in this bulletin, will esta lish a proper foundation for future efforts in breeding better and mo disease-resistant varieties. The field for such work is very larg Up to the present time most of the breeding has been for resistan to the late-blight (*Phytophthora infestans*), and this will continue to l the principal problem in the northern tier of States; but there is als much promise of success in securing new varieties to resist scab, dry rot, bacterial blight, and other troubles, which in the Southern an Western States are more injurious than late-blight. It is hoped tha potato specialists will give increasingly careful attention to this fea ture in their breeding and testing of varieties, for it is only by such general interest and effort that the desired information can quickly b secured.

ALBERT F. WOODS,
Pathologist and Physiologist.

OFFICE OF VEGETABLE PATHOLOGICAL AND
PHYSIOLOGICAL INVESTIGATIONS,
Washington, D. C., October 5, 1905.

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DISEASE RESISTANCE OF POTATOES.

INTRODUCTION.

Potatoes are liable to several diseases, some of greater economic importance in one part of the country, some in another.[a] The causes of most of these have been determined, and remedies of more or less practical value, chiefly spraying and seed disinfection, have been found. The success of the agents of the Department of Agriculture in securing disease-resistant varieties of various other plants has given an added interest to the question as to what may be expected in the way of securing disease-resistant varieties of potatoes. Inasmuch as this matter has engaged the attention of the potato specialists of Europe longer and more widely than has been the case in America, the attempt has been made to glean from their experience whatever may prove of assistance in furthering the work in this country.

In presenting the results it has seemed best for the sake of clearness to discuss briefly (1) certain general matters relating to potato culture in Europe; (2) the potato diseases which occur there, with comments on the resistance shown by particular varieties to each disease, and then (3) to summarize the information obtainable in America as to disease resistance of potatoes.

POTATO CULTURE IN EUROPE.

Potato culture was introduced from America into Europe more than three centuries ago. It was slower in its popularization there than in this country, but to-day the potato crop is relatively more important, both for food and for factory uses, in Europe than in America. This is partly attributable to the greater success of maize as a starch-producing plant in America and partly to the difference in economic

[a] Anyone not familiar with potato diseases should consult Farmers Bulletin No. 91, Potato Diseases and Their Treatment, by B. T. Galloway, which will be sent free of charge upon application to a Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C.

conditions—land and labor values and food habits—between the two continents. In the British Islands the annual acreage in the last decade [a] was more than one and a quarter million; in France three times and in Germany six times this amount. The crop in Great Britain is chiefly used for human food; in France about 40 per cent is used in starch and alcohol manufacture, and in Germany like conditions exist, with the use of the potato for alcohol distillation promising to increase largely.

It is the German national policy so to improve processes of culture and manufacture that potato alcohol may rival, if not displace, petroleum for lighting and fuel purposes. Various organizations are aiding in this movement, including the Deutschen-Kartoffel-Kultur-Station and the Institut für Gährungsgewerbe und Stärkefabrikation. These institutions, maintained partly by private endowment and membership and partly by government aid, have been in operation about fifteen years. Under the directorship of Profs. C. von Eckenbrecher and W. Delbrück, respectively, they give attention to all matters pertaining to potato culture, starch manufacture, and distillation, including the breeding, selecting, and trial of new varieties. They work in close cooperation with the various German experiment stations and private potato specialists. No similar institutions were met with elsewhere in Europe, although the potato growers of England have organized during the last year an association of much promise, the National Potato Society.

In any comparison of European with American varieties the difference in popular taste must be kept in mind. The English market is like the American in giving preference to varieties with white flesh, rich in starch, and in making little use of potatoes except for human food. On the continent of Europe, however, only the varieties with yellow flesh are rated as of first quality for table use. These are relatively poor in starch and richer in protein than the white-fleshed varieties, and when cooked they are not sufficiently dry and mealy to suit the American taste. On the Continent the white-fleshed, starch-rich potatoes are demanded by the starch factories and distilleries, and as a result continental potato breeders have aimed to develop white-fleshed varieties of high starch content and large productiveness, regardless of table qualities, and anyone importing their varieties for use in America must consider these facts. It is from England, therefore, that we may expect the more promising varieties.

It is worthy of note in this connection that the difference in character of the potato in popular favor in different countries is closely related to differences in methods of cooking. The varieties with yellow flesh are inclined to sogginess when baked or boiled, but are admirably suited for frying. The starch-rich white potato, which is of

[a] Sutton, A. W., Potatoes, Jour. Roy. Hort. Soc., XIX (1896), pp. 387–430.

highest quality when baked, may go to pieces if boiled and will not hold together sufficiently for frying. In the latter case steam cooking gives better results than boiling in water.[a]

The methods of culture of potatoes vary somewhat in different European countries, as they do in America. In general, closer planting is practiced than in this country, which is partly explained by the greater number of unskilled laborers in Europe. A matter of more pertinence to the present discussion is that much more attention is given, especially in England, to the source and handling of seed potatoes than is generally the case in America. The best informed English growers considered that this has much to do with the question of disease resistance, as will be explained later. Indeed, it has come to be accepted by them that, for the best results, seed potatoes should be imported from some more northern region, at least as often as every third or fourth year, and this is done by many large growers every year. English growers use Scotch seed very largely. On the grounds of Sutton & Sons, Reading, England, a comparative trial was conducted during the summer of 1904 with a number of varieties, using seed from Scotland, middle England (Lincolnshire), and southern England, respectively. When these plats were visited in August, the vigor of the plants was in all cases greatest from the Scotch-grown seed and least from that grown in the south of England. In certain varieties the development of the tops was as two to one. At the Cambridge University farms, located in the famous potato region of Lincolnshire fens, it was said that Scotch-grown seed did better than home-grown there and in the Lincolnshire district generally.

A large potato-growing company of the Canary Islands uses German in preference to English seed, because the growth from the latter is too rank and the tubers are too large. Potato growers on the island of Jersey in recent years have sent to England and Scotland for their seed. Italy and the Mediterranean islands look to France and Germany largely.

While some American potato growers recognize the importance of the source of seed and attend to this point consistently, there is generally indifference, disagreement, or lack of information on this subject, as Fraser[b] has recently shown. It is a matter deserving of further careful inquiry and experiment.

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[a] The writer is indebted to Professor Petermann for calling his attention to these matters. For a further discussion of this subject reference may be made to Petermann, A., Etudes sur la pomme de terre, Bul. de l'Inst. Chim. et Bact., No. 70, Gembloux (Belgium), 1901; and Coudon and Bussard, Annales de la science agronomique, I, Paris, 1897. To the latter, credit may be given for showing that the behavior of the potato in cooking is primarily dependent not so much on the total percentage of starch contained as on the relative percentages of starch and protein. The proper proportion of the protein is necessary to hold the starchy mass together when cooked.

[b] Fraser, S., The Potato, New York, 1905, pp. 51–52.

The relation of the maturity of seed to its value has also received considerable attention in Great Britain. Some of the best practical potato growers prefer to have potatoes intended for seed dug before they are fully mature, i. e., while the tops are still green and the outer skin of the tuber rubs up easily. These tubers are then allowed to lie on the ground a short time to "harden" in the light, i. e., to dry and be slightly sunburned, before they are put into storage.

The practice of "boxing" is common and very highly commended. This consists of setting the tubers with "seed end" up in shallow boxes or trays in a dry, light room for some weeks before planting, so as to have strong, short sprouts started upon them. In this way quicker germination, stronger young plants, and a perfect stand are secured.

The general preference in Scotland and in England is for planting small tubers, one and one-half to three ounces, planted whole. If larger tubers are used they are cut, as in this country.

OBSERVATIONS ON POTATO DISEASES AND DISEASE RESISTANCE IN EUROPE.

Insects cause the European potato grower little annoyance or loss as compared with American conditions. Nowhere in Europe, so far as learned, is any use whatever made of insecticides upon potatoes, leaf-eating insects being practically unknown. On the other hand, diseases caused by fungi or bacteria or of nonparasitic origin are even more common and destructive than in America. In the following paragraphs is a discussion of the nature and relative seriousness of such diseases as came under the writer's personal observation, coupled in each case with the evidence secured as to disease resistance. The less important and nonparasitic maladies are discussed first, reserving until later the consideration of the late-blight and rot.

CERTAIN MINOR DISEASES.

INTERNAL BROWN SPOT.

The peculiar disease of the potato called internal brown spot is as well known to plant pathologists and practical potato specialists in Europe as in America. The writer learned nothing more about it on the Continent than is set forth by Frank,[a] who reached only negative conclusions. It is considered not to be a parasitic disease, and no remedy is known and no suggestions are made except the doubtful one of avoiding the use of diseased tubers for seed. In England and Scotland several potato specialists[b] of wide experience gave evidence of like

[a] Frank, A. B., Kampfbuch gegen die Schädlinge unserer Feldfrüchte, "Buntwerden oder Eisenfleckigkeit," p. 211.

[b] Prof. J. H. Middleton, Messrs. Sutton & Sons, and Thomas A. Scarlett.

purport. The trouble is frequently observed, and is most commonly termed "sprain." It is not propagated in seed or soil and is non-parasitic. It is considered to be the direct result of malnutrition associated with unfavorable soil conditions, resulting either from too dry conditions or from the lack of potash or lime. It is frequent in light, dry soils during dry seasons, and is never seen on heavy, strong, moist soils. The remedy, in the judgment of the specialists cited, lies wholly in attention to cultural conditions and the choice of varieties.

Some varieties are more liable than others to internal brown spot and should not be used on soil that favors the disease; e. g., Mr. Scarlett stated that the British Queen variety is especially predisposed to "sprain." The primary remedy, however, lies in selection and treatment of the soil—i. e., in avoiding dry soil—and in so cultivating as to conserve moisture, while using lime and potash liberally.

FILOSITÉ, OR GROWING-OUT.

The names "filosité" and "growing-out" are applied in France[a] and England, respectively, to various forms of secondary outgrowths from tubers. Examples that were shown to the writer were in some cases merely "prongy" tubers, while in others stolons starting from the eyes produced secondary small tubers. Delacroix describes conditions where the seed tubers send out an abundance of weak shoots, both above and below ground, but these soon die without yielding any crop. The latter type is therefore allied to the curl disease of the potato.[b] The less serious forms of growing-out are attributed to climatic and soil conditions, especially to a long, wet autumn following a dry summer. The more serious types of the disease, especially as occurring in France, are attributed to varietal weakness or "running out." In both France and England the use of seed from any plants showing this tendency was condemned as tending to give a crop of generally reduced vitality.

LEAF-SPOT.

Since there has been a difference of opinion among pathologists as to the occurrence and destructiveness of the fungus *Alternaria solani* in Europe, the writer was led to keep an especially close watch for it. Prof. P. Sorauer kindly sent specimens from Europe some years ago corresponding fully with the leaf-spot disease caused by this fungus,

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[a] See Delacroix, G., Sur la filosité des pommes de terre, Jour. de l'Agriculture, December, 1903.

[b] Frisolée (French), or Kräuselkrankheit (German), is a common but not very serious potato malady of Europe, of which the cause is not clear, but apparently it is associated with varietal weakness and malnutrition. It is characterized by dwarfish plants bearing an excessive number of rather undersized leaves, which are down-curled and brittle. The tops have thus a dense or bushy appearance. They may be quite as green as normal plants.

and termed early-blight in America. It is known, therefore, that i occurs in Europe, but it can not be as common and destructive as it i here, for no trace of it could be found in any of the fields visited Much was seen, however, of a leaf-spot disease which bears a superficial resemblance to it. This was shown us first by Dr. Otto Appel i the experimental fields of the board of health at Dahlem, near Berlin Later it was seen elsewhere in Germany and in England. Apparently there has been a confusion of this with our American early-blight,[a] but both Doctor Appel and Professor Sorauer stated that there was n fungus present in this leaf-spot disease, and the writer's examination confirmed this. The cause of this trouble has not as yet been clearly established, but since Appel and Sorauer both have it under observation, further advice may be expected upon it in the near future. Opportunity was presented to compare the relative development of this trouble on different varieties in the trial grounds of the University Farm, Cambridge, England, in the latter part of the summer. There was a considerable difference in the amount of spotting of the various varieties, but none was altogether free from it.

SCABBINESS OF TUBERS.

POTATO SCAB.

Scab-like diseases, i. e., those characterized by surface erosions of the tubers, are frequent in Europe and apparently more varied in nature than is recognized to be the case in America. Yet nowhere does injury to the crop from such diseases approach that which is common in this country. This is in some ways surprising and unexplained. A disease closely resembling in appearance the common American type of scab was frequently seen, but growers everywhere in Germany, France, and Great Britain testified that it is not common or destructive enough to be of much practical importance. Scientific men are not agreed either as to the cause of the disease or as to the possibility of benefit from seed disinfection. But few recommended this treatment, and no practical potato grower was met who practiced it. The most puzzling thing, in the light of American experience, is that potatoes are grown year after year continuously or in the shortest of rotations on the same soil without increase of scabbiness. In each of these countries potatoes are often grown on the same soil for ten or twenty or even forty successive years with practically no trouble

[a] See Frank, Kampfbuch, p. 220. Apparently the disease mentioned above is the same as Frank's "Pockenfleckigkeit." Frank was altogether mistaken in considering it the same as the American "early-blight," as Sorauer subsequently showed. See also Bahna, J. J., Blattbraune der Kart.; Zeitsch. f. Land. u. Fortwirtsch., 2: 113 (March, 1904). Prof. C. von Tübeuf comments upon this article and reviews the literature in the June, 1904, number of the same journal.

from scab.[a] Since this is often on rich and heavy land, such as would develop scab under like treatment in America, the European experience is difficult to understand. Does not our type of disease exist there, or is it less virulent because of some difference in the climatic and soil conditions? The writer is not prepared to answer with full confidence, but his judgment favors the second suggestion.

Europeans, both pathologists and practical men, recognize more than one form of disease under the name of scab (the German "schorf," Dutch "schurft," French "la gale"). Frank's subdivisions[b] of "schorf" into four kinds—flach, tief, buckel, and buckel-tief schorf—were familiar to the continental pathologists interviewed, but the general opinion is that these are simply forms of one common disease, the variations being attributable to the season of attack or to varietal or vegetative conditions of the potato. Frank's specimens of "tief-schorf" were seen in the museum of the board of health at Berlin and have the appearance of the common American scab.

As to the cause, opinions differ.[c] The German pathologists who have given most attention to this disease consider the commonest German form to be due to a fungus similar to Thaxter's *Oospora scabies*, but perhaps not identical with it. In Holland doubt was expressed as to the common Dutch form of potato scab being a fungous disease at all, while in Belgium and France it is considered a parasitic disease, but due to bacteria (*Micrococcus pellicidus* Roze) rather than to fungi.[d] In England *Oospora scabies* is held responsible for only the minor part of the trouble, *Sorosporium scabies* Fisch. being the commoner parasite.

VARIETAL RESISTANCE TO SCAB.

As already stated, none of these scab diseases has proved of sufficient economic importance to attract much attention from practical potato growers in Europe. Probably most of the diseases would yield to the seed-disinfection treatment practiced for potato scab in America, yet this is nowhere used by European growers, so far as learned. The only valuable data as to the relative susceptibility of varieties to scab are those furnished by the reports of Professor Eckenbrecher,[e] whose results point to certain newer varieties as being comparatively free from scab, while others are quite susceptible. Age of the variety,

[a] See Sutton, A. W., Potatoes, Jour. Roy. Soc., XIX, pp. 387–430 (1896).

[b] Kampfbuch, p. 170.

[c] These conclusions are the result of conferences with a number of men and reference to the publications of others. Among those who have given this disease careful consideration in their respective countries and whose opinions were learned are Professors F. Krüger, Berlin; Ritzema-Bos, Amsterdam; Marchal, Gembloux; Roze and Delacroix, Paris; Massee and Cooke, England.

[d] Roze, E., Histoire de la pomme de terre, Paris, 1898, p. 275.

[e] C. von Eckenbrecher, Berichte Deutsch.-Kart.-Kult.-Stat., 1903 and earlier.

however, seems to be of less consequence than it is with the blight, for while one of the least resistant is Dabersche, an old standard, one of the most resistant is Richter's Imperator, also an old variety. Other varieties reported as preeminently scab resistant are Irene and Professor Wohltmann. Boncza and Pomerania are reported resistant, but to a less degree. Seed of all these have been secured for trial in this country. Early Rose is found especially liable to scab there as it is in America. It will be better, however, to postpone the discussion of resistance to scab as shown by American varieties of potatoes until the latter part of this publication.

OTHER SCAB-LIKE DISEASES.

Rhizoctonia.—This was seen on potato tubers in Europe even more commonly than it occurs in America, but most European pathologists regard it as nonparasitic. Those who consider it as a facultative parasite attribute little injury to it generally, although some think it capable of causing rot, as described by Frank.[a]

Spongospora solani Brun.—This fungus is said[b] to cause a scab-like disease in the north of Europe. This disease occurred[c] to a considerable extent on potatoes secured by the writer's order from Groningen, Holland.

Superficial scurvy diseases attributed to other fungi occur in Europe. Frank[d] describes one such caused by *Phellomyces sclerotiophorus*, but Doctor Appel told the writer that this had not proved serious in Germany. Johnson[e] reports it as causing some trouble in Ireland. In England another scurf disease of somewhat similar appearance is attracting attention. It occurred on the Eldorado seed potatoes imported with our order from Scotland, and the cause is apparently the fungus *Spicaria nivea* Hors.[f]

Oedomyces leproides Trabut.—This is a fungus[g] which attacks the young sprouts or eyes of the tubers, stimulating them to abnormal, cauliflower-like growth, of which the dark color has given rise to the popular name black-scab. The writer did not see this disease on the

[a] Kampfbuch, p. 194.

[b] Ibid., p. 176.

[c] Found and identified by James Birch Rorer.

[d] Kampfbuch, p. 182.

[e] Johnson, T., The Diseases of the Potato and Other Plants in Ireland, Journal, Dept. Agric. Ireland, Vol. III, No. 1 (1902).

[f] So identified by Dr. Ernst A. Bessey. Dr. Thomas Milburn, of the Midland Agricultural and Dairy Institute, England, advises the writer by letter that he is engaged in a special study of this disease. He finds it to occur on most English varieties, Evergood and Sutton's Flourball being by far the worst, while East Anglian and Sutton's Discovery are the only ones he has found entirely free from it.

[g] This also occurs on beet roots. See Massee, Geo. A., Textbook of Plant Diseases, p. 225.

Continent, but while in England Dr. M. C. Cooke sent specimens, as did also Dr. John Wilson, from Scotland. It is regarded as capable of causing much harm, but fortunately has not as yet become common.

POTATO STEM DISEASES.

BLACKLEG.

"Schwarzbeinigkeit," or blackleg, is a name applied to a disease seen commonly in central Europe. It is characterized by the blackening and rotting of the main stem, accompanied by a checking of the growth, uprolling, yellowing, and ultimate death of the leaves, and more or less rotting of the tubers. It has been exhaustively studied in recent years by Appel[a] in Germany, who concludes that it is due to bacteria (*Bacillus phytophthorus*, and perhaps other allied species), which either enter from the soil or are carried in the seed tuber. These start the disease below ground, the rot proceeding, as a rule, from the seed tuber to the young plant. Appel's conclusions are generally accepted by pathologists in Germany, Holland, and Belgium, and, so far as learned, in England.

The writer had opportunity to see much of the German disease in the vicinity of Berlin, and to verify Doctor Appel's observations, in a measure, in his own laboratory. Later (August) the same malady was seen in England, where it is said to be common, though apparently less troublesome than Appel reports it from Germany. All of the personal observations of the writer therefore lead to an indorsement of Appel's conclusions both as to the bacterial nature of the disease and as to its widespread occurrence and economic importance.

In France a similar if not identical disease is attributed to bacteria. Delacroix, who has studied this, considers the organism causing the disease, which he calls *Bacillus solanicola*, to be specifically distinct from that described by Appel. He kindly showed the writer specimens of the French disease in his garden in Paris, but it was in a stage so much more advanced than that seen in Berlin that a comparison of the two does not seem justifiable.

Of course, the possible occurrence of these stem diseases in America was kept in mind. The writer has never seen much, if any, of the same trouble in potato fields in the Northeastern States and adjacent Canada which have come under his observation. Certainly it is not so common in America as it is in Europe. The symptoms correspond, however, somewhat closely to certain diseases attributed to Rhizoctonia in the South and West.[b]

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[a] Appel, O., Arb. aus Biol. Abt. Gesundheitsamte, 3: 364 (1903).

[b] See especially Selby, A. D., Ohio Exp. Sta. Buls. 139 and 145, and Rolfs, F. M., Colo. Exp. Sta. Buls. 70 and 91.

The only remedies proposed or practiced for blackleg in Eurc consist in selection of sound seed, careful avoidance of rotten tub or those taken from a diseased crop, attention to rotation of cro since the germs may persist and accumulate in the soil, and the use disease-resisting varieties. None of these methods has been test carefully enough to establish its merits.

The chief evidence as to varietal susceptibilities or resistance blackleg is that of Appel.[a] He states that while no varieties ha been shown to be entirely free from the disease, the evidence is th thick-skinned, starch-rich, late varieties are in general more resi ant than thin-skinned, starch-poor, early varieties. The Dabersche finds to be the most resistant of the widely used German sorts, whi the Rose varieties are especially liable to blackleg. Contiguous pla of the Dabersche and White Rose in Doctor Appel's grounds show this difference very clearly at the time of the writer's visit in Jul 1904, the Rose being badly diseased, the Dabersche but slightly. A the Deutschen-Kartoffel-Kultur-Station distinct evidence of variatio in disease resistance was found. It was stated at this station that i the trial grounds the red varieties were in general found to be mo resistant than the white.

A considerable development of this disease was noticed at the Un versity Farm, Cambridge, England, where extensive variety trials wer being conducted. The observations of Mr. H. Henshaw, who had imme diate charge of these, were in agreement with those of Doctor App as to the association of the disease with the rot of the seed tuber, an he regarded it as a bacterial malady. There was a difference in th amount of the disease on different varieties, but Mr. Henshaw foun none wholly free from it. At the time of this visit Factor and Up-to Date were noticeably freer from the trouble than any other varietie there under trial. They were about alike in this, as, indeed, in al other characters. Doctor Delacroix cited as especially resistant to hi bacterial disease in France the variety La Czarine. He also state that the variety Geante Bleue is resistant, but to a less degree. Lau rent observed in his work on bacterial diseases that the maximum o resistance was shown by the varieties Chardon, Pousse-debout, an Chave.

OTHER STEM DISEASES.

Several other potato stem diseases have been reported in Europe, but since the writer did not study them in the field and learned nothing beyond what is recorded in literature they will be passed with brief mention. Prillieux and Delacroix have described another bacterial stem disease in France attributed to *Bacillus caulivorus*. Rhizoctonia is common on potato stems as well as tubers, but none of the patholo-

[a] Arb. aus Biol. Abt. Gesundheitsamte, 3: 408 (1903).

ists conferred with regards it as a parasite of importance on either. Professor Marchal, of Gembloux, said, however, that he sometimes found a basidiomycetous fungus, *Hypochnis solani* Prill.,[a] causing a blackleg-like stem disease in Belgium. Prof. T. Johnson, of Dublin, sent specimens of *Sclerotinia sclerotiorum*, which at times causes a destructive stem disease in Ireland, called "yellow blight." He also reports[b] the occurrence in Ireland of bacterial stem diseases, including what he believes to be the malady termed brown-rot in America and shown by Dr. Erwin F. Smith to be caused by *Bacillus solanacearum*. In none of these cases was anything learned as to relative varietal resistance to the disease in question.

LATE-BLIGHT AND ROT DUE TO PHYTOPHTHORA INFESTANS.

Late-blight and rot due to *Phytophthora infestans* occurs in Europe even more widely and destructively than in America, being recognized as the most important malady in all the countries visited by the writer—Italy, Austria, Germany, Holland, Belgium, France, and the British Islands. There was less unanimity of opinion than was anticipated as to the probable life history of the fungus, and consequently as to the remedial treatment. While all agreed that it lives over in the seed tubers, the opinion was frequently expressed, by scientific and practical men alike, that there is probably some hibernation in the soil, either in tubers left in the field or in the haulms. Possible hibernation in the tubers is to be associated with the fact that potato tubers left in the soil are not killed by frost in southern England and the south of Europe. The value of Bordeaux mixture as a remedy is recognized generally. Spraying is consistently advocated and practiced in the British Islands—especially Scotland and Ireland—the Netherlands, Italy, and portions of France. Germany has been surprisingly backward in accepting or even fairly testing this remedy. The reason seems to be that some of the experiments conducted by scientific men have shown injury to the plants, and so they have pronounced against it. No other remedial treatments are in common use. No one indorsed or practiced any method of seed disinfection. No particular culture methods were advocated or condemned other than attention to fertilization. There was a general agreement that excessive use of nitrogenous fertilizers, either chemicals or composted manures, increases the loss from this disease. Much attention is being given, however, to the relation of varieties and of source of seed to disease resistance, and the results are of sufficient importance to merit the somewhat detailed report which follows.

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[a] Probably identical with *Corticium vagum* var. *solani* Burt, which is the fruiting stage of the common Rhizoctonia of the potato.

[b] Johnson, T., Diseases of the Potato and Other Plants in Ireland, Journal, Dept. Agric. Ireland, III, No. 1 (1902)

RESISTANCE AS SHOWN TOWARD LATE-BLIGHT AND ROT.

HISTORICAL STATEMENT.

Doubtless examination of the earlier writings upon the potato disease known as late-blight and rot would show that from the beginning of its ravages differences have been observed in the resistance of varieties. Any such records of the thirty years from 1845 to 1875 would have no practical value now, since the varieties then in use have passed out of culture; nor would they have much scientific significance, owing to the lack of exact knowledge then as to the cause of disease. Going back to the origin of the varieties still in cultivation, it is found that in the early seventies an unusual amount of attention was focused upon the matter of the potato disease, as to causes and remedies. Ninety-four essays secured by the Royal Agricultural Society of England in 1872 showed agreement that an underlying cause was the degeneracy of the varieties then in culture.[a] The necessity for the production of new varieties was emphasized. The introduction of improved American varieties into England at about this period was most beneficial and stimulating to the potato specialists of that country.[b] These varieties were made the parents in further breeding. The best production of this revival was the Magnum Bonum, originated by James Clark from a cross of Early Rose with Victoria and introduced by Sutton in 1876. Experience with this variety laid the foundation for belief in possible disease resistance in potatoes both in England and on the Continent. Magnum Bonum soon became the standard main-crop variety of Great Britain and so continued until within the last fifteen years, when it yielded to Up-to-Date and others. It is still in considerable favor on the Continent.

Charles Darwin in 1877–78 became interested in the possibilities of disease-resistant breeding. Francis Darwin[c] states that Mr. James Torbitt, of Belfast, bred and selected varieties to secure disease

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[a] See Jour. Roy. Agr. Soc. Eng., XX : 291 (1884).

[b] Dean, A. Potato Improvement in the Past Twenty-five Years. Jour. Roy. Hort. Soc., XII : 41 (1890).

Mr. C. G. Pringle, who was then the foremost potato breeder in America, states that the demand from Europe for new American varieties was very active at that period, and continued until the fear of the Colorado potato beetle led to the prohibition by European governments of further importations of potato tubers from America. Thereupon Mr. Pringle supplied B. K. Bliss & Sons with specially hybridized potato seed, which was sent abroad in considerable quantity.

[c] Life and Letters of Charles Darwin, II, pp. 519–522.

The writer learns from Prof. T. Johnson, of Dublin, that Torbitt has been dead some twenty years. He was in the wine trade and raised varieties of potatoes for the berries, or seed balls, which he used as a source of material for wine. All of his varieties have disappeared except one coarse, red one, which was and is proof against disease.

resistance, his method being to cross-fertilize, rear the seedlings, and expose them ruthlessly to infection, retaining only those showing some degree of resistance. In this work he received much encouragement and some financial aid through Charles Darwin.

A committee of the English House of Commons, reporting in 1880 upon the potato disease, found all its witnesses concurring in the necessity for the production of new varieties with increased disease resistance.[a] Parliament was asked to give financial aid for experiments aiming to produce new and disease-proof varieties, but it did not do this. Earl Cathcart, in commenting on this report, states that—

> All potatoes have deteriorated in their disease-resisting powers. A variety from seed takes four to six years for its establishment, and under the most favorable circumstances a good variety might be expected to degenerate in twenty years. The production of new varieties is of national importance.

Apparently through the influence of Cathcart, Baker[b] was led to make an exhaustive comparative study of the genus Solanum in order to advise as to the relation of the cultivated varieties to the several wild species of the American continent preparatory to breeding experiments in which these might be used. As a result, two species were considered worthy of further trial in the attempt to improve disease resistance, viz, the Darwin potato, *S. maglia*, from the Chonos Archipelago, and the Uruguay potato, *S. commersonii*. Cathcart furnished Sutton with the former and he hybridized it with the common *S. tuberosum*. Sutton[c] reports that, beginning in 1886—

> Although many hundreds of flowers of *S. maglia* were artificially fertilized with pollen from cultivated varieties, only five were successful, resulting in five berries. From these but two seedlings were secured and only one of these showed any promise whatever, the second having to be grown under glass to prevent its dying. * * * This hybrid, although a vast improvement on *S. maglia*, is far behind the ordinary potato in appearance, crop, and quality. The seedling * * * grown for eight years, in 1894 was slightly diseased, although previously free from attack.

Sutton still has the *S. maglia* and this hybrid in propagation at Reading, where the writer saw them in August, 1904. Phytophthora was then more rampant on the foliage of both of these and on *S. commersonii*, which he also has, than on the average potato plants in his fields. No hybrids of *S. commersonii* had been secured by him previous to this. Mr. Lasham, potato specialist for the firm, has been giving renewed attention to the possibilities of species hybridization, and showed the writer balls which he considered to contain hybrid seeds of *S. tuberosum* × *commersonii*.

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[a] Jour. Roy. Agr. Soc. Eng., XX: 291 (1884).

[b] Baker, J. G., A Review of the Tuber-Bearing Species of Solanum. Jour. Linn. Soc., London, XX, 489–507 (1883–84).

[c] Sutton, A. W., Potatoes, Jour. Roy. Hort. Soc., XIX, 387 (1896).

Interest in the possibilities of *S. commersonii* has recently been stimulated by the experiments inspired in France by Prof. E. Heckel,[a] who believes in the economic possibilities of this species when improved by longer culture and perhaps by hybridizing, and has distributed it quite widely in France with this end in view. One French horticulturist, Labergerie,[b] claims already to have succeeded in producing a variety of edible quality, large yield, and superior disease resistance. This was seen growing in the grounds of Vilmorin-Andrieux & Co., at Paris. This firm was not yet convinced of the practical value of the plant, and since Labergerie refuses to send out any of these potatoes for trial at present, judgment must be reserved.

Returning to the consideration of the varieties of the common potato, it is found that during the last decade increasing attention has also been given to their comparative disease resistance. This has been well summarized by Prunet.[c] The main facts developed are as follows: Sorauer[d] in 1896 considered the evidence to date as showing that the highest degree of disease resistance was possessed by Magnum Bonum, the following showing some degree of resistance: Blaue Riesenkartoffel, Richter's Imperator, Athene, Reichskanzler. Rostrup,[e] writing about the same time from Denmark, places Magnum Bonum at the head as a disease-resisting variety, with Richter's Imperator and Champion as somewhat resistant.

In this connection it is noteworthy that Magnum Bonum has yielded its place in popular favor in Great Britain for main-crop purposes to Up-to-Date and other varieties, even while holding its reputation on the Continent. During the last decade these standard varieties in turn have been "running out," and the demand in England for something to take their place has stimulated potato breeders and seed specialists to direct their attention very generally to the development of a disease-resisting main-crop variety. The greatest efforts in breeding have been made during the last four years, while speculation in the most promising of the varieties produced has been at fever heat for the last two years, during which time many new varieties, more or less disease resistant, have been pushed to the front. There are now so many potato specialists in Great Britain breeding and handling varieties of reputed disease resistance that it is impracticable to mention all. Archibald Findlay,

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[a] Heckel, E., Sur le *S. commersonii*, Rev. Hort. de la Soc. d'Hort. et de Bot. des Bouches-du-Rhone, No. 581, pp. 200–206 (December, 1902); also, Contrib. à l'étude botanique de quelques solanum tuberiferes, Ann. de la Faculté des Sciences de Marseille, vol. 8 (1895).

[b] Labergerie, M., Le *Solanum commersonii* et ses variations, Bul. Soc. Nat. d'Agric. de France, March, 1904.

[c] Prunet, A., Le mildieu de la pomme de terre, Rev. de Viticult., XVII, 663; XVIII, 97 et seq. (1902).

[d] Zeitsch. f. Pflanzenkr., VI, 284 (1896).

[e] Tidsskrift f. Landbrugets Planteavl, 1895, 1896, 1897.

of Mairsland, Auchtermuchty, Scotland, has originated some varieties of high repute; Sutton & Sons, of Reading, England, have also taken a prominent part in this work. Scotland-grown seed of all the leading varieties can be secured from Thomas Scarlett, of Edinburgh, and Mr. Scarlett has some promising varieties of his own introduction. Anyone desiring more specific information should secure the publications of the National Potato Society from its secretary, Walter P. Wright, Postling Vicarage, Hythe, Kent, England.

Meanwhile the German Potato Station has been making extensive tests, doing some breeding and encouraging several potato breeders.[a] These efforts have not been directed primarily to disease resistance, but the station has taken note of this feature and published the data regarding all varieties tested.

While the results of this work in Europe have been collected or correlated by no one, the writer was able to gather considerable information, in addition to that already referred to, from conversation with potato specialists, especially in Great Britain. This, together with what has been learned in America, is made the basis of the following discussion. It is to be regretted that it is impracticable to give detailed credit in some cases to those who kindly furnished the information.

THE MEANING OF DISEASE RESISTANCE.

Although potato specialists, especially in England, apply the term "disease proof" to their favorite varieties, this is not to be taken literally. No variety has as yet shown itself to be absolutely proof against disease. The writer personally collected leaves infected with the blight fungus from two varieties which were said to be "disease proof." Absolute resistance against the blight fungus has not as yet been and may never be secured. Varieties are known, however, which show a relatively high degree of disease resistance. This may be shown in the delay in date of appearance of the blight on the leaves or its slower progress after appearing, and still more clearly in the relatively small amount of loss from rot of the tubers. Most of the exact observations made in Europe have been based on this latter difference.

DISEASE RESISTANCE AND VEGETATIVE VIGOR.

Disease resistance and vegetative vigor are closely associated, although the factors involved are not necessarily identical. In any consideration of the problems of the life and death of the potato plant it must be remembered that the potato has two natural methods of

[a] The most active of these are Paulsen, Cimbal, Richter, and Dolkowski. Graf Arnim-Schlagenthin, of Nassenheide in Pommern, is an extensive breeder and dealer in new varieties, as is also F. Heine, of Hadmersleben.

reproduction, the true seed produced in the berries or "balls" following the blossoms, and the tubers produced below ground. Reproduction by seed is a sexual process, that by tubers is vegetative. Both are exhaustive of vitality. The two are in a certain sense physiologically opposed to each other and can not well be carried on at the same time by the plant. Under the natural conditions of the wild potato plant in Mexico, and doubtless elsewhere, seed production precedes tuber formation. In Europe and northern America, with a shorter season and intensive culture, the two processes overlap. As a result there is, just after the potato plant comes into blossom, a period when the natural tendencies within the plant toward seed production above and tuber formation below are such as to subject it to unusual physiological stress. This has been termed the "critical period" [a] in the development of the potato plant.

Usually the blossoms fall without the setting of the fruit, and the plant then passes into a stage where its energies are devoted to tuber formation alone. Once well started upon this vegetative period, its growth is more or less indeterminate, i. e., there is no clearly defined natural terminus to the life of the cultivated potato plant. Instead, there is the gradual decline in vegetative vigor which may prepare the way for early-blight and other diseases characteristic of weakling plants. It is noteworthy that the destructive attacks of the late-blight fungus occur, as a rule, after the blossoming period has passed. So far as the evidence goes it seems to suggest that high vegetative vigor enables the plant to ward off in some degree the fungus attack.

There is, moreover, a natural decline in vigor, or "running out," with the age of the variety. The length of life of a variety depends upon numerous conditions, and is an indefinite matter in any case. It is ordinarily placed by potato specialists at from twelve to twenty years. As a variety begins to "run out" it apparently shows, among other things, a lessened degree of general disease resistance. Thus Magnum Bonum had the highest reputation in this respect from its origin in 1876 until about 1890 in Great Britain. On the Continent it has remained longer in favor. Up-to-Date has held a like place during the last decade in Great Britain, and Richter's Imperator has a similar record in Germany. These statements are based upon the popular verdict, not upon exact experiments; but the belief that disease resistance decreases with the age of the variety is firmly established in the minds of specialists in potato culture in Great Britain, at least so far as concerns resistance to Phytophthora.

There is little definite evidence regarding the relation of vegetative vigor to resistance to other diseases, but so far as it is formulated it

[a] See Jones, L. R., Certain Potato Diseases and Their Remedies, Vermont Exp. Sta. Bul. 72: 4 (1899); also The Diseases of the Potato in Relation to Its Development, Trans. Mass. Hort. Soc. (1903), Part I: 144.

favors the general applicability of the idea. The production of berries, or seed balls, is held by some English breeders to be an indication of such vigor, and therefore presumably of disease resistance, although no one claims that the absence of these is equally strong evidence in the opposite direction. It is worthy of passing note that berries are formed much more commonly in Europe, especially in Germany and Holland, than in America, apparently because of climatic differences.

THE RELATION OF HYBRIDITY TO DISEASE RESISTANCE.

By a "new variety" of potato, as the term is commonly used, is meant one recently developed from the seed. Sports may appear and are indeed frequent in some varieties. These will, however, be mentioned later. The seed in all cases presumably represents a sexual origin, i. e., comes from a fertilized flower, but this may have been either self-fertilized or cross-fertilized. One would expect greater vigor to result from the cross-fertilization, and potato breeders are of the opinion that it is secured. On the other hand, while varieties recently originated from seed may show a high degree of disease resistance, this is not necessarily the case according to the verdict of English and German breeeders, many new varieties proving as susceptible as old ones.

Reference has already been made to the work of Cathcart and Sutton in England and of Heckel and Labergerie in France based on the hope of advantage from using one or another of the wild Solanums for such hybridizing. There are interesting possibilities along this line, since there are many wild forms of *S. tuberosum* in addition to other species of tuberiferous Solanums. Thorough trials of these are now being made by Stuart [a] at the Vermont Experiment Station which will be reviewed later in this paper. It should be emphasized at once, however, that while the use of the wild Solanums does offer interesting possibilities, there is no record of practical success from their use, if we except the doubtful one of Labergerie's variety of *S. commersonii* previously referred to. On the other hand, great practical improvements have been secured by various breeders from crossing varieties of cultivated potatoes.

IMPROVEMENT BY SELECTION.

All plants tend to vary. One of the commonest ways to improve plants is by selection from among the varying individuals. For the first two years after their origin, variants, or "rogues," are not uncommon with the seedling potato, but the variety is "fixed" by the weeding of such rogues before it is distributed for general culture, and

[a] Stuart, W., Disease-Resistant Potatoes, Vermont Exp. Sta. Bul. 115 (May, 1905).

thereafter very little variation occurs. Some modification is to be expected, nevertheless, and among other things there may be variation in disease resistance. It seems worth while, therefore, to keep a lookout for individual plants which show especial resistance to the blight when this is epidemic about them. The tubers of such individuals deserve to be carefully saved apart and planted, in order that it may be seen whether their resistance is a fixed and inheritable character or the result of some chance difference in environment. Such selection has already been undertaken by three persons to our knowledge: Appel in Germany,[a] Stuart in Vermont,[b] and Fraser in New York;[c] but no practical results have as yet been secured.

ARE EARLY OR LATE VARIETIES THE MORE RESISTANT?

The blight never becomes serious until the midseason of potato growth is passed; thus in our Northern States its worst ravages come in August and September. Therefore early varieties, as a rule, escape. But this is simply because they mature before the blight is epidemic. So far as evidence has been secured, both in America and Europe, when the early varieties are planted late enough to expose them to the disease alongside of the later ones, the early varieties as a class suffer the worst. For example, the most complete destruction by rot which the writer ever saw was with a late crop of Early Ohio potatoes attacked by the disease in September. Woods,[d] of Maine, has also found early varieties especially susceptible.

RELATION OF SOURCE OF SEED AND CULTURAL METHODS TO DISEASE RESISTANCE.

The opinions of highly intelligent potato growers in Great Britain are especially worthy of note. One of the first concerns with them is the source of their seed. Mention has already been made of the experiments at Sutton's grounds, showing the superiority of northern-grown seed. It was found to be the general verdict of practical men in Europe that northern-grown seed is more highly disease resistant, as well as more productive. If one is to aim for the best results in health of crop, therefore, attention should be directed to quality and source of seed as well as to variety.

Practical men as well as scientists generally agree that methods of culture also determine to a considerable degree liability to disease. These act not only indirectly as they affect moisture content or other physical conditions of the soil, but more directly as they affect the

[a] Appel, Otto. Die diesjährige Phytophthora-epidemie, Deutsche Landw. Presse, XXIX: 685 (1902).

[b] Vermont Exp. Sta. Bul. 115, p. 139.

[c] Reported in correspondence.

[d] Woods, C. D., Maine Exp. Sta. Rpt., XIX: 181 (1903).

vigor or inherent disease resistance of the plant itself. Seed dealers in this country, as well as in England, have also expressed a preference for seed from a crop that has not been very highly fertilized, especially with nitrogenous manures. The most detailed study along this line is that of Laurent,[a] whose results indicate that nitrogenous fertilizers predispose both the foliage and the tubers of the plants to the attacks of Phytophthora. This is in harmony with the general opinion of practical potato growers, that high manuring increases the liability to disease.

COMPOSITION AND CHARACTER OF TUBERS AS RELATED TO ROT RESISTANCE.

There is considerable evidence that the chemical composition of the tubers bears a direct relation to resistance to rot. Paulsen[b] claimed that varieties rich in nitrogen compounds are less resistant to disease than those rich in starch. He classed most of the early varieties in the first category and found the larger percentage of the second class to be of the late varieties. The table varieties of better quality were also of the first category.

Petermann[c] has recently made field and laboratory studies at the Belgium Experiment Station. These led him to practically the same conclusions, viz, (1) that varieties richer in amids are more liable to rot, although of superior table quality; and (2) that varieties relatively richer in starch, including several recently originated German factory varieties, are less liable to rot but are of inferior quality for table use.

Sorauer[d] has published similar conclusions, and he made more detailed statements as to his belief on this point in conversation last summer. In general, he believes that the varieties richer in protein are more liable to disease, while those richer in starch are more resistant. This probably explains his observation that the yellow-fleshed varieties, which are in higher repute in Germany for table use, are more liable to disease[e] than the white-fleshed varieties which are grown for factory purposes. His further observations in harmony with this idea are that the thicker and rougher skinned red varieties[f]—e. g., Dabersche—have a higher degree of disease resistance, coupled with relatively high starch and low protein content, whereas the thin-skinned white varieties, which are more liable to the disease, have

[a] Laurent, Recherches exp. sur la mal. des plantes, Ann. Inst. Past., XIII, pp. 1–48 (1899).

[b] Biedermann's Centralbl. Agr. Chem., 1887, p. 107.

[c] Bul. Inst. Chim. et Bact. Gembloux, 70 (1901).

[d] Jahresber. d. Sondersaussch. f. Pflanzensch., XII and XIII (1902 and 1903).

[e] See evidence of this also in Jahresber. d. Sondersaussch. f. Pflanzensch., XIII, 1903.

[f] See also statement that red varieties are in general more resistant; Jahresber. d. Sondersaussch. f. Pflanzensch., XII, 1902.

proportionately less starch and more protein. As a rough empirical test he considers that if, when a fresh tuber is cut open, the flesh browns quickly on exposure to the air and the vascular bundles darken soon, it is evidence of high protein content, and therefore of liability to disease, whereas the reverse condition is evidence of probable disease resistance. Professor Sorauer also emphasized to the writer his belief in the relation of soil, manuring, or other cultural condition to disease resistance. The testimony secured elsewhere in Germany, as well as from American sources, is in harmony with these ideas so far as it goes.

While character of skin is probably a less reliable index to rot resistance than is chemical composition, yet the writer has learned of several potato experts in America, as well as others in Europe, who regard the red varieties, especially such as have a rough skin, as less liable to rot than are the white thin-skinned varieties. The Dakota Red has often been cited as an example of this class in America. Abundant evidence can be found, however, especially from English experience, of high disease resistance coupled with a thin, white skin. Breeders aiming at disease resistance need not turn from the white-skinned varieties.

CHARACTER OF STEM AND FOLIAGE AS RELATED TO DISEASE RESISTANCE.

In connection with the question of the relation of the character of the stem and foliage to disease resistance it is not safe to go far in generalizing. Mr. Lasham, potato expert and breeder with Sutton & Sons, considers that a stem that is strong, rough, and hard, almost woody at the base, is an important character if the plant is to be most highly disease resistant. The nature of the foliage is considered by others to be of greater importance, the preference being for small leaflets, rough and relatively thick rather than large and flabby. A rich dark-green is preferred to the lighter colored foliage. It seems inherently probable that the character and color of foliage should stand in close relation to the other matters which have with more certainty been shown to be related to disease resistance, viz, general vigor and capacity for starch manufacture. Those giving further attention to disease resistance may, therefore, well bear these suggestions in mind.

DISEASE-RESISTANT VARIETIES OF EUROPE.

When all the factors are considered, two important things become evident: First, that no variety will maintain its disease-resistant qualities indefinitely, losing them sooner in one locality than in another; second, that no one variety will be equally disease resistant in all countries, i. e., what is best suited to one may not be to another.

Hence we must expect much conflicting evidence regarding the same variety, especially as grown under different conditions and in different countries.

The most satisfactory way will be to summarize separately the evidence obtained in each country visited in Europe, followed by that from America.

The greatest activity in breeding for resistance occurs in Great Britain, and next to this in Germany, while France has recently shown special activity in one line. There were secured from each of these countries all the varieties of especial promise for trial in America—comprising a total of nearly one hundred. By no means all of these have an established reputation as being highly disease resistant, although all will be tested for this as well as other characters.

Experience has shown that the transference of a variety from Europe to America, or the reverse, is likely so to disturb the equilibrium of the plant that the developments of the first year are scarcely normal. At least two years are necessary for the adequate testing of imported varieties. Commercial growers should therefore make only trial plantations of any European variety until its adaptability to American conditions has been proved. Seed of the varieties secured will be under trial at several points this season and next. While it does not seem worth while to publish the full list of these in advance, the following are selected as representing the varieties or types most strongly indorsed in their respective countries for disease resistance.

GREAT BRITAIN.

More attention has been given to this question in Great Britain than anywhere else. Careful comparative observations are recorded as to the relative disease resistance of all the leading varieties. The last report of the National Potato Society specifies the following eight varieties as the best for disease resistance, named in the order of their merit. The writer appended certain facts as to the origin and characters of each. All are white skinned, white fleshed, of excellent quality, of high general vigor, and heavy yielders.

TABLE I.—*The most disease-resistant varieties of potatoes in Great Britain, as announced by the National Potato Society.*[a]

Order of merit.	Name of variety.	Originator.	When sent out.	Season.
1	Evergood	Findlay	1896	Medium late.
2	Discovery	Sutton	1903	Late.
	Royal Kidney	Findlay	1896	Second early.
3	Northern Star	do	1901	Late.
4	Sir John Llewelyn	Harris	1900	Early.
5	King Edward VII	Butler	1901	Medium.
6	Eldorado	Findlay	1903	Medium late.
7	Factor	Dobbie	1898	Late.

[a] Annual Report, National Potato Society, I: 36 (1904).

Two points brought out by the foregoing table are worthy of especial note: First, the remarkable success of one man in producing four of these eight varieties, showing that there is something more than chance in their development; second, the comparatively recent origin of all. For the latter fact there is probably a double explanation: (1) The loss of disease resistance with age of the variety; (2) the remarkable activity of British potato breeders during the last few years, with the aim above all else of securing increased disease resistance.

It should be remarked that there are a number of more recent introductions which promise to rank with the best of these varieties, but they have not as yet been so fully tested.

GERMANY AND HOLLAND.

The potato-growing industries of Germany and Holland have much in common, and similar or identical varieties are used. Data were not available for making so definite a selection as in Great Britain. The following are probably representatives of the highest grade of disease resistance achieved:

TABLE II.—*The most disease-resistant varieties of potatoes in Germany and Holland.*

Name.	Originator.	Season.	Color of skin.
Mohort	Dolkowski	Late	White.
Irene	Paulsen	Medium late	Red.
Geheimrat Thiel	Richter	do	White.
Professor Wohltmann	Cimbal	Late	Red.
Boncza	Dolkowski	Medium late	Do.
Eigenheimer	(Holland)	Medium early	White.
Paul Krüger	do	Late	Do.

The first five varieties have been imported from Germany. All of these are of the white-fleshed, starch-rich type which is being developed there primarily for factory rather than for table use. They are, however, reputed to be of fair quality except, perhaps, in the case of Irene. These, like the British varieties, are of comparatively recent introduction.

The Holland varieties are of a similar type except that Eigenheimer has a yellowish-tinted flesh.

FRANCE AND BELGIUM.

The conditions are similar in France and Belgium. Neither country has varieties of much promise for trial in our Northern States. In Belgium the varieties recommended as being most highly resistant to blight and rot were the recently originated German factory types like those already mentioned, to which might be added Topas and Professor Maercker. The verdict in France was similar, Professor Maercker again being commended, along with the English varieties

Magnum Bonum and Royal Kidney. The indorsement of these comparatively late, white-fleshed, starch-rich potatoes in France and in the other continental countries is the more significant when one remembers that the chief aim with potato specialists there is to produce the yellow-fleshed potato rich in protein.

DISEASE-RESISTANT VARIETIES OF AMERICA.

Until two or three years ago no systematic attempt was recorded, so far as the writer has learned, to determine the relative resistance to blight and rot of potato varieties in America. Of course this would not imply that individual growers have not observed these differences, but they are rarely matters of record, and as a rule are based only upon limited observations. Only two or three potato-seed dealers are advertising disease-resisting varieties with any prominence this year, and these are in all cases comparatively new and little-tried sorts.

INVESTIGATIONS AT THE EXPERIMENT STATIONS.

Promising investigations have been inaugurated at several of the State agricultural experiment stations which should soon supply data for more reliable conclusions than are now possible. Woods,[a] of the Maine station, and Green,[b] of the Minnesota station, have each reported results of variety trials as to disease resistance.

Woods found a marked difference in the ability of varieties to withstand both blight and rot. As a rule the earlier varieties were soonest attacked. The variety Rustproof showed the highest degree of foliage resistance and also the least rot, viz, only a little more than 1 per cent, whereas the average of all varieties under trial was more than 30 per cent.

Green found that the loss from rot varied widely with varieties, ranging from 1 per cent in the most resistant to 40 per cent in the least resistant types. Potatoes of the type of Sir Walter Raleigh and Rural New Yorker resisted rot better than those of any other class. Of the 49 varieties tested, only two, Clay Rose and an unnamed seedling, were practically free from rot. These trials will be continued.

Observations on disease resistance have also been made by Macoun at the Central Experimental Farm, at Ottawa, Canada. He has kindly advised the writer, in correspondence, of his conclusions. The following varieties have shown especial disease resistance as judged by appearance of blight on the foliage: Holburn Abundance and Professor Maercker are most resistant, with Swiss Snowflake, State of Maine, and Rural Blush only a little less so.

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[a] Woods, C. D., Maine Exp. Sta. Report, XIX: 181 (1903).

[b] Green, S. B., Potatoes at the University Farm, Minn. Exp. Sta. Bul. 87 (1904).

WORK AT THE VERMONT STATION.

The most extensive work on potatoes has been done by Stuart, who two years ago inaugurated at the Vermont station variety trials as to disease resistance, supplemented by breeding experiments. Professor Stuart has kindly supplied the following summary of his results to date:[a]

Eight varieties were under trial in 1903—Dakota Red, Enormous, Green Mountain, Rustproof, Squire, Sir Walter Raleigh, and two of Manum's unnamed seedlings. In 1904 the same varieties were used, with the addition of June, Mammoth Gem, Minister, New Queen, State of Maine, Sutton's Discovery, nine more of Manum's seedlings, *S. commersonii* from Doctor Heckel, of France, a Peruvian variety from the United States Department of Agriculture at Washington, and four Mexican varieties furnished by Mr. C. G. Pringle. The latter included two cultivated varieties termed Monterey and Mexican, and the two wild species, *S. polyadenium* and *S. stoloniferum*. Observations have been made as to both foliage and tuber resistance. As to foliage, none was wholly free from blight, but there was a marked difference, some being quickly and entirely destroyed, while others suffered only slightly. In 1903 Rustproof headed the list in this respect, and Dakota Red was second. In 1904 those showing greatest foliage resistance were as follows, in the order of their resistance: Monterey, *S. commersonii*, *S. polyadenium*, Rustproof, Sutton's Discovery, June, Mexican, Mammoth Gem, and Manum's No. 3. Dakota Red did not equal its 1903 record.

Judged by resistance of tubers to rot, Dakota Red made the best showing of the varieties which were tested for two seasons, but there was some rot in it both years. Of those added to the series of 1904 several varieties gave a crop of tubers entirely free from rot, namely *S. polyadenium*, *S. commersonii*, Sutton's Discovery, June, and the two Mexican varieties. It is noteworthy that these are likewise the varieties which showed the least blighting of the foliage. Possibly the absence of rot is in some degree attributable to the lessened amount of infection of tubers from vines in consequence of this, although there were adjacent plants showing badly diseased foliage.

Selection.—In 1903 a few plants in the varieties grown were observed to remain green longer than the others. The tubers from these were saved and were planted in 1904 along with others of the same variety that succumbed much earlier. So far as could be noted no increased disease-resistant qualities were transmitted to the offspring of these plants.

[a] For further details see Stuart, W., Disease-Resistant Potatoes, Vermont Exp. Sta. Bul. 115 (May, 1905).

In view of the limited number of varieties tested and the consequent restricted scope of observation, it would hardly be justifiable as yet to give an expression of opinion as to the probable outcome of such a line of investigation. These observations are to be continued on a much larger scale the coming season.

Hybrid and other seedlings.—Seedlings were grown in 1903 from the Mexican species supplied by Mr. Pringle—*S. polyadenium*, *S. stoloniferum*, and *S. bulbocastanum*. This number has recently been augmented by *S. verrucosum* and a wild form of *S. tuberosum*. In 1904 some of these were successfully hybridized with the cultivated potato.

While it is yet too early to say very much regarding the possibilities of developing a commercially desirable disease-resistant variety of potato through the hybridization of wild species with our cultivated varieties, there seems good reason for believing that improvement may result from such crossing, especially as to disease resistance.

In addition, a large number of seedlings of the common potato were grown in 1904. Among this number several vigorous-growing plants were noted, which remained quite green up to the time of digging. Some 50 of the more promising of these were saved for trial the coming season. Selections were based on vigor of vine, size and yield of tubers, and freedom from rot.

One of the most interesting and instructive features of the seedling experiment was the object lesson it presented of the extreme vigor of some of the plants, showing quite plainly that one of the best sources for increasing the vigor lies in the production of new varieties from seed. Proper fertilization and good tillage are also important aids in increasing the vigor and disease-resisting powers of the vine.

While the data in hand do not warrant broad generalizations, the following inferences are drawn by Professor Stuart:

(1) Some varieties are less subject to vine injury than others.

(2) Some show a greater tuber resistance to rot than others.

(3) With some there seems to be a fairly close relation between resistance of vine to disease and of the tuber to rot.

(4) Selection has not given visible increase of resistance.

(5) Hybridization and the growing of seedling plants, followed by careful selection, seem to offer a more logical method of securing disease-resistant varieties than does selection.

INFORMATION SECURED BY A CIRCULAR OF INQUIRY.

In order to secure all information possible as to the relative merits of the varieties now before the public, a circular letter of inquiry was sent recently to various experiment station officers and to about two

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hundred potato specialists in the United States and Canada[a] asking their opinions and the basis for them. There was a surprising lack of agreement upon any one variety as being especially disease resistant. The replies indicate several things: (1) That very few American potato specialists have up to the present time given careful attention to this question; (2) that there are few varieties in common use which have preeminent worth as disease resisters; and (3) that in so large a geographical area local conditions affecting culture and disease are so widely variant as to prevent close comparisons or broad generalizations. No less than 38 varieties were commended as showing resistance to blight or rot. Of these, 26 were commended only once, while the other 12 were favorably spoken of by two or more persons. Still other varieties were mentioned, but not with sufficient positiveness to entitle them to a place in the following list. Those named more than once, with the locality in which they were indorsed, are as follows:

TABLE III.—*The best varieties of potatoes in the United States and Canada, as reported by various experiment station officers and potato specialists.*

Variety.	Number of indorsements.	Localities in which commended.
Dakota Red	10	Canada (4); Maine (3); Massachusetts; Michigan; New York.
Irish Cobbler	5	New York (2); Maine; Ohio; Rhode Island.
Green Mountain	5	Maine (2); Massachusetts (2); Vermont.
Doe's Pride	3	Maine (2); Michigan.
Norcross	3	Maine; New York; Vermont.
White Beauty	2	Maine; Minnesota.
Professor Maercker	2	Canada; Rhode Island.
Ionia Seedling	2	New York.
Quick Lunch	2	Pennsylvania; Vermont.
Rustproof	2	Vermont.
Sir Walter Raleigh	2	Minnesota; New York.
Vermont Gold Coin	2	Pennsylvania; New York.

The following varieties were mentioned once each, the commendation coming from the locality mentioned in parentheses: American Wonder (Minnesota); Babbitt (Maine); Bonanza (New York); Boss (Vermont); Buffalo (Maine); Burbank (New York); Cambridge Russet (New York); Carmen No. 3 (Ohio); Clarke's Pride (Maine); Clay Rose (Minnesota); Crines Lightning (New Jersey); Delaware (Minnesota); Enormous (New York); Gem of Aroostook (Rhode Island); Gloria (Rhode Island); Harris Snowball (New York); Holborn Abundance (Canada); Imperial Mills Prize (Maine); Keeper (New Hampshire);

[a] The writer is indebted to the following experiment station officers for helpful advice: Professors Macoun, Canada; Woods, Maine; Rane, New Hampshire; Stuart, Vermont; Brooks, Massachusetts; Wheeler and Adams, Rhode Island; Fraser and Stewart, New York; Buckhout, Pennsylvania; Halsted, New Jersey; Selby, Ohio; Taft, Michigan; and Green, Minnesota. Much information has been secured from the replies of leading potato growers and seed dealers. It is regretted that it is impracticable to give detailed credit to these correspondents.

Professor Kuehn (Rhode Island); Million Dollar (Michigan); Orange Blossom (Vermont); Rural New Yorker No. 2 (Vermont); Scabproof (Wisconsin); Squier (Vermont); Star of the East (Maine); State of Maine (Canada); Swiss Snowflake (Canada); Virgirosa (Vermont); Westfield (Vermont); White Scotch King (Minnesota). In addition three unnamed varieties received favorable mention from Vermont.

From these reports it is observed that certain varieties like Dakota Red, Rustproof, and Keeper have very well proved powers of disease resistance, but lack other desirable characters to make them popular varieties. Several of the standard main-crop varieties are in some degree disease resistant, and doubtless owe their general popularity, in a measure, to this fact, although it has not been clearly defined. To this group belong Carmen's best productions—Carmen No. 3, Sir Walter Raleigh, Rural New Yorker No. 2, and Rural Blush—Green Mountain, State of Maine, Delaware, Enormous, and White Beauty. Irish Cobbler is highly spoken of as disease resistant, but it is a question whether this may not be in part due to its early maturity, by virtue of which it escapes the worst ravages of Phytophthora.

There is also a very promising series of new seedlings which should be carefully watched as to disease-resisting characters, among which may be especially mentioned Norcross, Star of the East, and Babbitt (Johnson Seed Company); Vermont Gold Coin (Burpee); Ionia Seedling (Dibble); Harris Snowball (Harris & Co.).

It is encouraging to learn from the replies that several of the newer German and English varieties which are reputed disease resisting in their home countries have upon trial in America made a good showing. This is evidenced by the reports from the Rhode Island and Canada stations favorable to Professor Maercker, Gloria, Professor Kuehn (German), Holborn Abundance (English), and Swiss Snowflake.

RESISTANCE TO SCAB.

It is a matter of common observation that some varieties of potatoes are more liable to scab than are others. Reference has been made earlier in this publication to conclusions to this effect reached in Germany. So far as known the only American publication recording the results of comparative trials as to scab resistance is that made by the Vermont Agricultural Experiment Station in 1901–2.[a] Thirteen varieties were tested in 1901 and fourteen in 1902 in soil badly infested with scab germs. While all showed some scab, there was a considerable difference in the amount. Sir Walter Raleigh made a good showing both years, but an unnamed seedling sent by Mr. A. E. Manum, his No. 56, was more highly resistant. These trials established the writer's confidence that still more resistant strains may be secured by

[a] Jones, L. R., and W. J. Morse. Vermont Exp. Sta. Report, XV: 225 (1902).

breeding and selection. Prof. William Stuart, of the Vermont station, has undertaken this work in connection with the development of resistance to blight and rot.[a] He has made further trials during the last two years, but without conclusive results as yet.

A request for information as to relative scab resistance was inserted in the circular of inquiry, already referred to, recently sent to American potato specialists. Most of the replies to this question were negative in character, but a number gave interesting information, some of which is especially pertinent. The strongest evidence as to scab resistance comes from Mr. Hiram Presley, of Port Huron, Mich., a potato specialist, who has tested hundreds of varieties during the past thirty years. He commends the Cambridge Russet as practically exempt from scab. Mr. Frank Paddock, of Perry, N. Y., gives like evidence.

Carmen No. 3 is highly spoken of as scab resisting by several growers in Ohio, New York, and Vermont, but one Michigan correspondent condemns it.

American Giant receives strong indorsement from Freehold, N. J., and vicinity; Salzer's Scabproof from Wisconsin, and Aurora from Vermont. Favorable reports come from New York regarding Sir Walter Raleigh and Irish Cobbler, and from Canada regarding McIntyre.

The following were each commended by one correspondent from the localities mentioned in parentheses: Best (Maine); Doe's Pride (Maine); Early Freeman (Ontario); Keeper (New Hampshire); Seneca Beauty (Michigan); Squier (Vermont); White Beauty (Michigan); White Elephant (New Jersey); White Scotch King (Minnesota).

On the other hand, the Early Ohio and some of its seedlings are condemned as especially liable to scab. Early Rose, Bliss Triumph, and Beauty of Hebron are also reported to scab badly.

It is encouraging to note that in some cases the same variety is rated as in a high degree resistant to both diseases, the scab and the late-blight and rot. A similar coincidence will be found if a comparison is made of the lists of German varieties showing resistance to the several diseases discussed earlier in these pages, and the same thing was observed in some degree with the English varieties.

This indicates that the attributes which give power of resistance against one disease are not incompatible with those operative against another. Indeed, it is not unlikely that the general characteristics of disease resistance may prove to be similar or the same for these various maladies. If so, it will prove the easier to secure the model potato, which, while possessing that which is desirable in quality and productiveness, shall, in addition, show the highest degree of resistance to the various diseases. This is an ideal worth striving for.

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[a] Vermont Exp. Sta. Bul. 115, p. 139.

SUMMARY.

The aim of this bulletin is to present in concise form what is known about disease resistance of potatoes. Much of this information is from European sources.

Certain minor diseases of obscure nature, but apparently nonparasitic, are first considered—the internal brown spot, filosité, and leaf-spot. Among remedial measures for each is the selection of resistant varieties.

Scab diseases of tubers are in most, and perhaps in all, cases of parasitic origin—fungous or bacterial. Apparently the variety of these is greater in Europe than in America, but the severity is less in Europe. It is undecided to what extent the American type of scab occurs in Europe, so a close comparison of conditions and remedies is not practicable. In Germany certain varieties are known to be more scab resistant than others, among them being Richter's Imperator, Professor Wohltmann, and Irene. The same is true in America, Cambridge Russet leading the list, so far as is known. Other American varieties showing a considerable degree of resistance are Carmen No. 3, American Giant, Sir Walter Raleigh, and Irish Cobbler. Scabproof and Aurora are also highly commended for scab resistance.

Various stem diseases of the potato are known. The commonest type in Europe is termed blackleg (Schwarzbeinigkeit), a bacterial disease. It is not known to occur in America, but it resembles certain maladies which do occur here and which are as yet imperfectly understood. Varietal resistance to blackleg is not fully established, but apparently Dabersche and certain similar thick-skinned, starch-rich late varieties are more resistant than thin-skinned, starch-poor early varieties of the Rose type. Factor and Up-to-Date showed a considerable degree of resistance to blackleg in England. La Czarine and other varieties are reported to show resistance to a bacterial stem disease in France.

The late-blight and rot due to the fungus *Phytophthora infestans* occurs more commonly in Europe than in America. Attention has been given for many years to relative varietal susceptibility to this disease, especially in Great Britain and in Germany. Varieties of superior disease resistance are known in both countries, and a number of the most promising from these and other European sources have been imported for trial.

The following statements are tentatively formulated as to the nature of resistance toward blight and rot and the character of the varieties exhibiting it:

(1) Disease resistance in potatoes is relative, not absolute, no variety known being wholly proof against late-blight and rot.

(2) It seems related to general vegetative vigor, and is therefore in a measure dependent upon cultural and developmental conditions and tends to decrease with the age of the variety.

(3) It can be restored by originating new varieties from seed, especially of hybrid origin. Not all seedlings show superior disease resistance.

(4) The use of other species of tuber-bearing Solanums for hybridizing offers some promise, but no practical results have yet been secured.

(5) Possibly the disease resistance in established varieties can be improved by selection, but this has not been proved.

(6) Early varieties may escape the disease by maturing before it becomes epidemic, but when similarly exposed they are as a class less resistant than late varieties.

(7) The source of seed tubers is a matter of importance, northern-grown seed giving plants of superior disease resistance in Europe. Seed from a crop that was not too highly fertilized is probably preferable. Possibly tubers are better for seed purposes if dug before they reach full maturity.

(8) High fertilization, especially with nitrogenous manures, lowers the power of the plant to resist both blight and rot.

(9) Varieties relatively rich in starch are more resistant to rot; those richer in protein are more susceptible to it.

(10) So far as skin characters are an index, the red varieties with thick and rough skin seem more resistant as a class than the thin-skinned white varieties.

(11) So far as stem and foliage characters are concerned, the evidence favors the stem that is hard, rough, and rather woody at the base, and the leaf that is small, somewhat rough, and dark colored.

The varieties rated highest as to disease resistance in England are Evergood, Discovery, Royal Kidney, Northern Star, Sir John Llewelyn, King Edward VII, Eldorado, and Factor.

In Germany and Holland the following represent the best types: Mohort, Irene, Geheimrat Thiel, Professor Wohltmann, Boncza, Eigenheimer, and Paul Krüger.

In Belgium and France no improvement as to disease resistance has been made over the best English and German types.

In America, trials as to disease resistance have been conducted at some of the experiment stations, notably in Vermont, where experiments in breeding and selection for increased resistance are under way. These results have been correlated with information recently secured by a circular of inquiry addressed to a large number of potato specialists in the Northeastern States and in Canada. From these it appears that a wide variation is shown in disease resistance among the varieties now in cultivation in America, but that no one variety is preeminent.

Among those which have been widely tested, the following deserve mention as of the resistant class: Dakota Red, Rustproof, Irish Cobbler, Sir Walter Raleigh, Doe's Pride, and White Beauty. Certain European varieties of the disease-resistant type seem to retain that character when grown in this country, e. g., Professor Maercker and Sutton's Discovery. There is much of promise in certain new varieties under trial at the Vermont station. Several new sorts of reputed disease resistance have recently been placed on the market by American seedsmen, e. g., Harris's Snowball, Dibble's Ionia Seedling, Burpee's Vermont Gold Coin, and Johnson's Norcross, Star of the East, and Babbitt. Those having opportunity should carefully observe the relative disease resistance of these and also of other new varieties.

The evidence at hand seems to justify the hope that the coordinated efforts of potato specialists working from both the practical and the scientific standpoints may soon result in the development of varieties of potatoes combining general excellence with a high degree of disease resistance. All who can do so are urged to aid toward the accomplishment of this end.

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VALLEY AT SECANQUIM, ALTA VERA PAZ, GUATEMALA, THE SCENE OF EXPERIMENTS WITH WEEVIL-RESISTING COTTON.

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U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 88.
B. T. GALLOWAY, *Chief of Bureau.*

WEEVIL-RESISTING ADAPTATIONS OF THE COTTON PLANT.

BY

O. F. COOK,
BIONOMIST IN CHARGE OF INVESTIGATIONS IN THE AGRICULTURAL ECONOMY OF TROPICAL AND SUBTROPICAL PLANTS.

ISSUED JANUARY 13, 1906.

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1906.

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SCIENTIFIC STAFF.

O. F. COOK, *Bionomist in Charge.*

G. N. COLLINS, *Assistant Botanist.*

F. L. LEWTON, *Scientific Assistant.*

H. PITTIER, *Special Agent.*

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., September 26, 1905.

Sir: I have the honor to transmit herewith a report on "Weevil-Resisting Adaptations of the Cotton Plant," and to recommend it for publication as Bulletin No. 88 of this Bureau. This report has been prepared by Mr. O. F. Cook, bionomist in charge of investigations in the agricultural economy of tropical and subtropical plants. It contains an account of his observations and experiments which show that some of the varieties of the cotton plant have definite weevil-resisting characters. The establishment of these facts opens new and unexpected lines of approach to cultural solutions of the weevil problem.

The investigation of cotton referred to in this report was begun in March, 1904, through the Laboratory of Plant Breeding, there having been set aside for it from the emergency cotton boll weevil appropriation a part of the funds which had been devoted to the breeding of weevil-resistant cotton. The existence of a field culture of cotton in the presence of the boll weevil had been ascertained by Mr. Cook during a visit to Guatemala in 1902, and it was hoped that the immunity of the cotton might prove to be due to some weevil-resistant quality.

The first result of detailed observations was the discovery of the weevil-eating kelep or so-called Guatemalan ant, which has been made the subject of previous reports through the Bureau of Entomology. It now appears that the usefulness of this insect is not limited to the boll weevils which it catches and kills. By making a regular field culture of cotton possible in the presence of the boll weevil it has contributed in an important manner to the development of the weevil-resisting characters here described. The cotton plant, it seems, has been greatly modified in protecting itself against the ravages of its insect enemy. Not only has it attracted the kelep to its service and developed other means of defense which are more

direct, but even the lint, on the peculiar character of which the commercial value of the crop depends, appears to find its chief use to the plant in excluding the weevil larvæ from the seed. Our Sea Island and Upland varieties have been raised for long periods in regions where the boll weevil did not exist and, as was to have been expected, are largely lacking in protective features. The Kekchi cotton, on the other hand, which has continued its development in a weevil-infested region under the protection of the keleps, has by far the largest number of weevil-resisting characters.

The fact that weevil-resisting adaptations really exist, as shown in numerous instances in the present report, emphasizes the necessity of a thorough study of our cultivated cottons for the purpose of taking advantage of any and all protective characters.

It is possible, as Mr. Cook suggests, that the Guatemalan variety of cotton which he has discovered, and which has such a surprising number of weevil-resisting adaptations, may not prove suited to cultivation in the United States, but even in that case the value of the present paper on weevil-resisting characters would not be diminished, for it will serve as a help to all who may engage in seeking and developing such characters in the types of cotton now cultivated in our country.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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WEEVIL-RESISTING ADAPTATIONS OF THE COTTON PLANT.

INTRODUCTION.

The fact that Central American varieties of cotton have developed weevil-resisting adaptations has already received preliminary notice.[a] A third visit to Guatemala, in the spring of 1905, has given opportunity for further studies of the protective characters of the native varieties and for comparing them with the types of cotton now cultivated in the United States. For this purpose plantings of Upland and Sea Island varieties have been made in Guatemala, and as the season advanced other tests of the Guatemalan and United States varieties were arranged under very different climatic conditions in Texas and at Washington.

These opportunities of comparative observation have revealed a series of protective adaptations of such number and nicety as to furnish a unique and well-nigh incredible instance of selective development. The statement of the former paper may be repeated with emphasis, that the presence of the weevil-eating kelep has enabled the Indians of eastern Guatemala to maintain since very ancient times field culture of cotton in the presence of the weevils, with the result that there has been developed a dwarf, annual, short-season variety with numerous features which, in the absence of sufficient numbers of keleps, afford material assistance in protecting the crop against the ravages of the weevil.

Whether this Guatemalan cotton can be made of direct use in the United States or not, it demonstrates the existence in the cotton plant of weevil-resisting characters. The new variety has lint of good length and quality, so that its utilization in the United States depends upon its adaptability to our climate and methods of culture.

As already explained in publications devoted to the kelep, the weevil-eating propensities of that insect were discovered in 1904 during a visit to Guatemala which had been undertaken in the hope of finding a weevil-resisting variety of cotton. It had been observed

[a] Cotton Culture in Guatemala. Yearbook of the United States Department of Agriculture for 1904, 475–488; Science, N. S., 20: 666–670, November 18, 1904.

two years before that a field of dwarf cotton cultivated by the Indians did not suffer from the boll weevils, though these pests were abundant on a "tree cotton" a short distance away.

The kelep afforded an entirely unexpected and yet very striking explanation of the fact that cotton was being grown as a regular field crop in a region which had probably been infested with weevils for many centuries, if it were not, indeed, the original home of the species. That there was an insect in existence specially qualified by structure and habits to attack, disable, and devour the boll weevil, was welcome news in the United States, and in accordance with cabled instructions from the Secretary of Agriculture numerous colonies of the keleps were brought home and colonized in the cotton fields of Texas.

The finding of the kelep explained the failure of the weevils to prevent cotton cultivations in eastern Guatemala, and seemed at first to diminish the prospects of weevil resistance in the cotton itself. Nevertheless, the intention of studying Guatemalan varieties of cotton and the cultural methods in use in that country was not abandoned, and the results are not without bearing on the original question of the causes of the apparent immunity of the Guatemalan cottons, and also upon the more practical question of securing cotton varieties and cultural methods by which the injuries of the boll weevil in the United States may be reduced to a minimum.

The Guatemalan cotton protected by the keleps is a genuine Upland variety, very early and productive, with a fiber of good length and texture, as already stated. In addition to features which directly favor the keleps, it has many other qualities which may render it useful, even without its insect guardians. In former reports it has been compared with the very early Upland varieties, such as King and Parker; but comparative tests made in eastern Guatemala show that the native variety, which it is proposed to call *Kekchi*, represents a very distinct type of this important cultivated plant. It belongs to *Gossypium hirsutum*, the Upland species or series of varieties, in the sense that it is not a Sea Island, Egyptian, or Kidney cotton,[a] but it is distinctly more different from any of the Upland varieties now cultivated in the United States than these are from each other. It has not been ascertained that the Kekchi cotton in its

[a] The Sea Island cotton is so called because cotton of this type is cultivated on the Sea Islands of South Carolina, long famous for the excellence of their product. The Sea Island cotton came originally from Barbados, whence also its botanical name, *Gossypium barbadense*.

Upland cotton gained its name as a means of distinguishing it from the Sea Island, being cultivated in the interior, or "upland," districts of the Southern States. The Upland type of cotton was recognized as a distinct species by Linnæus under the name *Gossypium hirsutum*, but many subsequent writers

present form is suited to cultivation in the United States, but it has, without any doubt, new and significant characters which must be regarded as factors in cultural solutions of the weevil problem. (Pl. II, fig. 1.)

Although cotton was not found to be planted as a regular field culture in any localities in Guatemala where the keleps do not exist, small quantities are produced in the interior plateau region about Rabinal by what may be called dooryard cultivation, and these, too, have suggested cultural factors and expedients which may not be without practical bearing.

The present paper can claim to make only a beginning in the bionomic study of the question, but it shows at least that the weevil problem has many avenues of approach on the botanical side.

The cotton of Guatemala and neighboring countries has maintained an existence, at least, in the presence of the weevils, and has suffered an acute natural selection with reference to its ability to protect itself against the weevil or to secure the assistance of allies, such as the keleps. That no commercial cotton crop is raised or exported from such districts does not prove that they are unworthy of scientific investigation, or that they are not likely to yield materials and suggestions of practical value in meeting the invasion of weevils which is now so serious a menace to the cotton industry of the United States.

Some of these weevil-resisting adaptations have been of use in securing for the cotton the assistance of the keleps. There are others which, if properly utilized, might render these interesting insects unnecessary. Tropical America has been serving for thousands of years, evidently, as a laboratory for this class of experiments. Texas was invaded only yesterday—a decade ago. Now that we are forced to engage in the strife, the first preliminary should be, it would seem, to take stock of the weapons which nature has forged.

The present report was planned and partly written before the discovery of the true nature of the best of the weevil-resisting adaptations—the proliferation of the tissues of the buds and bolls. Some of the characters here described may have no value except as suggestions, but taken together they may be of interest as an outline of the results of the very long period of selection to which the presence of the boll weevil has subjected the Central American varieties of the cotton plant.

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have erroneously confused it with the Old World species *Gossypium herbaceum*, which is not cultivated in the United States, though often so reported.

The Egyptian and Kidney cottons belong to the Sea Island series, and are of American origin. The Kidney cottons seem not to have been cultivated on a commercial scale, but they are very widely distributed in tropical America. The name refers to the fact that the seeds of each compartment of the boll are grown together into a small compact mass, in shape suggesting a kidney.

SELECTIVE INFLUENCE OF THE BOLL WEEVIL.

The boll weevil exerts a most prejudicial effect upon the cotton crop, but, unlike most parasites, it does not cause disease or debility in its host plant. The young buds and bolls are merely pruned away, as it were, the purposes of the weevil being the better served when the plants remain vigorous and continue to produce more buds and bolls, in which more eggs can be laid and more larvæ brought to maturity. Nevertheless, if no bolls are allowed to develop no seed can be set. The fate of the cotton crop in wet seasons in Texas shows that without some form of protection the plant would have been extinct long since in all localities reached by the boll weevil.

The long contact between the boll weevil and the cotton plant in Central America has given ample opportunity for the latter to profit by the selection which the insect itself has provided. Every difference by which a cotton plant was able to resist or to avoid the weevil and thus ripen more seeds than its fellows would give it a distinct advantage, quite as if the selection were consciously carried on by the planter or the plant breeder. The case is different from that of the recent improvements of many of our cultivated plants by selection for the increase of some particular quality already existing. Such improvements can often be made appreciable, or even highly valuable, in comparatively few years, but under the desultory Indian methods of cultivation long periods of time would be required for the origination and accumulation of such characters as these protective adaptations.

Climate and other local conditions must also be taken into consideration. An adaptation which would be effective in one set of climatic conditions may be of little use, or even a positive disadvantage, in others, as, for example, the prompt shedding of the parasitized buds. In a dry region the falling of a bud to the superheated sun-baked earth insures the death of the weevil larva, either by the heat directly or by the complete drying out of the tissues in which the larva is embedded. In the moist districts of eastern Texas, however, this expedient is quite ineffective, the larvæ often developing even better when the buds fall off and lie on moist soil than when they remain attached to the plant.

It need not surprise us to learn also that the weevil-resisting adaptations shown by the Kekchi and other cotton varieties of Central America are shared, to some extent, by those already known in the United States, since the whole Upland type of cotton appears to have been, originally, a native of the Central American region. Varieties which reached the United States from Mexico and the West Indies may, however, have had little or no contact with the weevil for many centuries, while in Central America the struggle for existence has remained severe and continuous down to the present day.

It is now known that in the plateau region of Mexico the long dry season effectually excludes the weevil, so that varieties of cotton from the Mexican highlands, instead of being weevil-proof, as sometimes represented, may have no immunity whatever when brought into the much more moist climate of the cotton belt of the United States.

The Kekchi cotton of Guatemala, on the other hand, has to a much greater degree than any of the varieties now grown in the United States the very qualities which experiment has shown to be effective for the mitigation by cultural means of the injuries inflicted by the boll weevil. That it has, in addition, other features not possessed by our United States varieties, or not hitherto interpreted as weevil-resisting adaptations, need not be looked upon as anything outside the normal order of nature, but is entirely in accord with what appears to be the biological and agricultural history of the cotton plant in Central America.

GENERAL PROTECTIVE CHARACTERS.

DWARF HABIT AND DETERMINATE GROWTH OF KEKCHI COTTON.

Although Guatemala is a tropical country and the climatic conditions are suitable for the growth of cotton throughout the year, the Kekchi cotton is cultivated only as an annual, and is smaller and more determinate in its habits of growth than the Upland varieties now known in the United States. It soon attains its full height, and after a crop of bolls has set on the lower branches there is a definite tendency to cease growing or producing new buds. The later upward growth of the plants seems to be supplementary, as it were, to the formation of the bolls; often there appear to be no more flowers formed, and many of those which come seem to be undersized, as though the plant were really mature and were approaching the natural termination of its existence. Our Upland varieties, on the contrary, continue to produce throughout the season hundreds of small squares on each plant which serve only as breeding places for the weevils.

The explanation of the high development of these short-season qualities of the Kekchi cotton is doubtless to be found in the custom of the Indians, who pull up the cotton as soon as the bulk of the crop has ripened to make room for the peppers, which are always planted with the cotton. For the Indians the peppers are an even more important crop than the cotton, so that when the time comes for clearing away the cotton they do not wait for the plants which may have delayed maturity. Late bolls, even, would never come to maturity or furnish seed for planting. The result has been a very long-sustained selection for early bearing and uniform ripening of the crop. Some of our earliest Upland sorts may begin blossoming

as soon as the Kekchi, but they show far less tendency to determinate growth.

The development of earliness has been assisted, no doubt, by the climatic conditions which prevail in eastern Guatemala. The rainy season oftens begins before the cotton harvest is completed, so that the later bolls are very likely to become diseased, or, if they reach maturity and open, the lint is often beaten to the ground and made too dirty for use in spinning and weaving. In either case the seed is not harvested.

The Indians believe that even if they did not pull the cotton up it would not become a perennial, but would die out completely, even to the roots, during the rainy season. Seeds scattered accidentally in the plantation at harvest time are rotted by the rain and do not germinate, so that little or no volunteer cotton is carried over from one season to another.

If the Kekchi cotton were the only variety planted in Guatemala and the weevil had there, as in the United States, no other food plant than the cotton, the insects might all die off between April or May, when the cotton is pulled up, and October, when the next crop is planted. There is, however, enough perennial "tree" cotton in the country to keep the pest from becoming exterminated. Moreover, the question of additional food plants in Guatemala is still open.

The importance of securing short-season varieties of cotton for the United States can hardly be overestimated, since, as already intimated elsewhere,[a] there is no longer any reason to hope that the more severe winters of the northern districts of the cotton belt will give any protection against the weevils.

As long as the weevil was confined to the southern part of Texas, where the cotton could survive the winter, the destruction of the plants as soon as possible after the maturing of the crop was the only measure calculated to seriously reduce the number of weevils. It was also essential to plant cotton as early as possible in the spring to avoid the weevils bred on the volunteer, or hold-over, cotton which negligent planters had left in the ground. The extension of the pest farther north and the possibility of securing cotton varieties with determinate habits of growth introduce several new considerations. The hold-over cotton is eliminated from the problem, but in the more northern latitudes, where the cold comes earlier and the temperature remains lower throughout the winter, it may often happen that there will be no period in which the weevils can be reduced by starvation, unless time can be secured for this purpose in the spring by the planting of short-season varieties of cotton.

[a] Cook, O. F., 1905. Progress in the Study of the Kelep, Science, N. S., 21: 552.

Instead of colder winters being unfavorable to the weevils, there is every probability that cold sufficient to keep them in a torpid, inactive condition will preserve their noxious lives much better than warm and pleasant weather, which enables them to continue active and thus deplete their vital energies. The winter of 1904–5 was one of unprecedented severity in Texas, both in absolute temperature and in continued cold and wet, and yet the weevils were able, in many localities, to infest heavily the early plantings of cotton to a far greater extent than in previous years.

The farther north the locality the more will the efficiency of cultural methods of avoiding the boll weevil depend upon the planting of quick-maturing varieties of cotton. It is true that in a favorable season the cotton planted first would set its crop soonest, and thus escape a part of the damage suffered by adjoining fields of later growth, the earlier fields breeding weevils to attack in larger force the later plantings. But instead of insuring a decrease of the number of weevils in a given locality and checking the propagation of the pest, very early planting by a part of the farmers of a community might tend, after an early fall and a cold winter, to the opposite result, since it would save the lives of large numbers of weevils which would otherwise perish before the cotton, if sown a few weeks later, would be large enough to furnish the weevils with food. Dr. Herbert J. Webber states that planting could probably be deferred even to the middle of June without impairing the chances of a crop as large as that which can be obtained in the presence of the weevil.

There would seem to be little object in planting cotton where the weevils are as abundant as in some places in southern Texas in the spring of the present year, 1905. Nevertheless, the opportune occurrence of a few weeks of dry weather was able, even then, to greatly improve the prospects of a crop. No matter how bad the weevils, the planter still has hope that dry weather may come and save his crop from being a total loss. As long as indeterminate varieties are planted this possibility will always make it difficult to carry out a general policy of early destruction of the plants.

Some of our Upland varieties of cotton are early enough in the sense that they begin flowering and fruiting very promptly, but unless the season is very dry they will produce a continuous succession of buds until they are pulled up or frost cuts them off. The earliness of practical value is not to be shown merely by the date of flowering, but by the date of ripening the crop of bolls and of ceasing to form new buds in which weevils can breed. If the improvements noted in other parts of this report can be realized in practice, it would no longer be necessary to destroy the cotton plants

in order to put an end to the breeding of the weevils. It would then become practicable and desirable to regulate planting so as to bring the growing period of the cotton at the most favorable season for a rapid development of the crop, and thus to give the weevils the shortest possible opportunities for breeding.[a] If the fall and winter had favored the survival of many weevils, planting could well be deferred until the weevils had disappeared, a fact which could be ascertained by starting early a few observation plants from which the weevils could be carefully picked by hand as long as they continued to appear.

The extent of the mortality of the boll weevil in the spring has been well shown in the investigations reported by Mr. W. D. Hunter on the effects of applying Paris green to the very young cotton as a means of destroying the weevils which had lived through the winter. Numerous dead weevils were found in the poisoned fields, but equal or even greater numbers were found in those to which no Paris green had been applied, and the conclusion was drawn that a large proportion of the weevils, which pass the winter in a state of hibernation or torpidity induced by the cold, perish through starvation or other causes in the spring, after the weather has become warm enough to render them active again and permit them to renew their search for cotton plants on which to feed and lay their eggs.[b]

It is easy to understand, too, that after the weevils have been reduced by the cold to a condition of inactivity involving an almost complete suspension of the vital functions, the lack of food and the lapse of time can make very little difference with them. Starvation comes much quicker during warm weather while they are going actively about, so that it is the autumn and spring which must be relied upon to reduce the numbers of the weevils rather than the cold periods of the winter months. Messrs. Hunter and Hinds have also noted as significant the fact that of weevils captured at the middle of December, 15.8 per cent passed the winter successfully, while of another lot captured a month earlier, only 1 per cent survived. Their conclusions were as follows:

> It is evident that the weevils which pass the winter and attack the crop of the following season are among those developed latest in the fall and which, in consequence of that fact, have not exhausted their vitality by oviposition or any considerable length of active life.

With these facts in mind it becomes plain that no objections need be raised on general biological principles to the introduction of new

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[a] A determinate variety of cotton would also avoid the cultural disadvantages incidental to very early planting, for if the weather happens to turn cold and wet the cotton is often either killed outright and has to be replanted or, what is still worse, it becomes permanently stunted and unproductive.

[b] Hunter, W. D., 1904. The Use of Paris Green in Controlling the Cotton Boll Weevil, Farmers' Bulletin No. 211, U. S. Department of Agriculture.

quick-maturing varieties of cotton from tropical countries on the ground that cold weather will exclude them from the United States. The early spring is the only time in which they will be likely to encounter adverse conditions in this respect, and if varieties can be secured which are able to mature a satisfactory crop in a short season, these quick-maturing qualities will far more than compensate for any lack of ability to withstand cold weather in the early spring.

The Kekchi cotton may prove, however, to be quite as tolerant of cold as the other Upland varieties now cultivated in the United States.[a] In its native country it is planted in October and grows throughout the winter months in mountain valleys where temperatures of between 40° and 60° F. are not infrequent. (Pl. I.)

VARIATIONS IN THE KEKCHI COTTON.

Very great diversity of size, habit of growth, and other features exists in the Indian cotton of the vicinity of Secanquim and Cajabon. The plants cultivated by Mr. John H. Kinsler on the United States system were also very different from any grown by the Indians, being much more robust and compact than in the more crowded native fields. The spreading lateral branches and low, compact growth of the Kekchi cotton, as shown in Plate II, figure 1, might have cultural disadvantages if these tendencies were to be maintained in regular field cultures. Such, however, is not likely to be the case. When growing closer together the plants are more upright and less leafy below.

To what extent the differences observed thus far represent varietal characters can scarcely be determined without a field test of the apparently different strains, side by side. The broken, precipitous nature of the country renders it impossible to rely upon comparisons of the conditions of the different fields.

The conservative agricultural habits of the Indians would tend to the continued planting by one man or family of the same seed for long periods of years, which might well conduce to the formation of separate strains. The low germinating power of the seed may possibly be due to such inbreeding, though it is more likely that it deteriorates because of the humidity of the climate.[b] Nevertheless, our experiments were sufficient to prove that even among plants grown from seed raised by the same Indian there were very appreciable

[a] This was shown to be a fact before the report was printed. See p. 18.

[b] The Indians appreciate the fact that the cotton seed does not germinate well. They are accustomed to plant six seeds together, from which two or three plants usually reach maturity, often with one or two insignificant dwarfs underneath. The yield per plant in these crowded fields is naturally very small, but the larger individuals often bear from 20 to 30 bolls. At Rabinal from 6 to 10 plants in a cluster is the rule, the product of the individual being still further reduced.

differences, sufficient to have a very practical bearing upon the question of securing strains having the special characters required in the United States. Indeed, there was nearly as much diversity among the Guatemalan plants as among all the Upland varieties, though these were in some cases unusually variable, as a result apparently of the transfer to new and unwonted conditions of climate and soil.

The usual number of locks or cells in a boll of the Kekchi cotton is four, but bolls containing three or five are not uncommon; often they are on plants which have otherwise the usual number.

There is also considerable diversity on the same plant in the shape of the bolls, some, for example, remaining quite conical and pointed, while others round out to near the apex. One plant was observed in which the bolls were very nearly spherical. The involucre was also unusually large. The plant had an unusually deep red or blackish color, and was distinctly more vigorous than its neighbors, as often happens with mutations.

It is not at all probable that a close selection has ever been practiced by the Indians, so that a wide diversity of mutational characters may be expected when once the variety has been brought under careful observation.

The stems and petioles of the Kekchi cotton plant are dark red, or at least spotted with red, and the leaves turn dull red with maturity. The bracts and bolls are green when young, but with age and exposure to the sun become more or less tinged or spotted with red.[a] The outer involucral nectaries also turn deep red, especially the two upper ones, even while the buds are still very young. The great majority of the leaves are simply three-pointed, but many of them have an additional smaller lateral point on each side near the base.

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[a] One plant at Secanquim showed a very decided instance of variegation with white and red, though the latter color might have been due to an increased tendency of the white portions to take the red discoloration common on normal leaves. The lower branches of the plant show only normal green coloration, and a part of the upper branches is also normal in color and size, and with fruits rather above the average size. The variegated branches do not regularly alternate, nor do they come all from one side, but they might still have connection with the phyllotaxy. There seem to be two stages of the variegation, a white and a light greenish-yellow; the latter may belong only to young leaves. Both are distributed with the utmost irregularity, and both may affect the upper surface of the leaf while the under surface remains green, or vice versa, though the latter condition is much less common than the former. The etiolated portions of the leaves, involucres, and fruits do not attain the full size of the corresponding normal organs, so that the parts affected are more or less unsymmetrical, though where the variegation is slight this result may be apparent, or if it be complete the symmetry is not affected. Except for two premature bolls the seed was not ripe, and these were from the normal lower part of the plant.

EFFECTS OF GUATEMALAN CONDITIONS ON UNITED STATES VARIETIES.

The behavior of the United States varieties under changed climatic conditions in Guatemala is interesting in several ways. The "King," which in the United States appears to resemble the Guatemalan variety most nearly, here loses most of its distinctive characters and breaks up into a variety of types, many of which would not be recognized in the United States as at all related to King. One of these is a "limbless" or "cluster" variety, which for a time appeared to Mr. Kinsler as a very promising new sort. It was smaller and distinctly earlier than King plants of the normal type, and seemed likely to be more productive, but only a few bolls developed, and these proved to be of abnormal form, with deep grooves or notches across the tip.

One of the features in which the change of climate seems to produce remarkable effects is that of earliness. The King, which in the States is looked upon as the earliest variety, is found by Mr. Kinsler to be somewhat exceeded in this respect by "Allen," which has not been looked upon as a competitor. The Sea Island and Egyptian varieties, too, prove to be much more precocious than was expected. Some of them begin flowering almost as soon as the Upland sorts. The Rivers variety of Sea Island cotton, in particular, was very early, robust, and productive, distinctly ahead of the near-by Jannovitch, though not so tall.

ACCLIMATIZATION OF KEKCHI COTTON IN THE UNITED STATES.

It was not unexpected that the Kekchi cotton would show a change in its method of growth on being transferred to Texas. New conditions of soil and climate often cause notable disturbances of the organism. Some of the tropical cottons planted in Texas for experimental purposes have grown into large bushes without showing the slightest tendency to produce fruit or even flowers. In 1904 cotton from Peru planted at Victoria, Tex., grew most vigorously to a height of 18 feet, but remained quite sterile. It is possible, however, that even in their own country these were what are called "tree cottons," which usually grow to considerable size before beginning to flower. Letters from Mr. Kinsler, in charge of our experimental plot at Pierce, Tex., relate a similar behavior on the part of the Kekchi cotton, which at that place has grown large and rank; but toward the end of July it was beginning to fruit, so that the ripening of seeds in Texas is to be anticipated.

Two or three years will probably suffice to diminish this abnormal vegetative vigor, due to the stimulus of the new conditions, and permit a return to the normal earliness of the variety. Similar results

have attended the introduction into Texas of Mexican varieties of corn. The plants grew 14 feet high the first year and bore very little seed; in the following seasons they became smaller, earlier, and more productive.

The probability that the Kekchi cotton can be grown even at the northern limits of cotton cultivation is strongly indicated by the results of an experiment at Lanham, Md. (1905). In favorable seasons cotton can be grown to maturity as far north as Washington, but the present year has been very unfavorable, the summer months being for the most part cool and rainy, and with several intervals of unusually low temperature. The cotton, which was planted intentionally in rather poor soil, to avoid too great luxuriance of growth, germinated very badly and remained small and stunted until August. The Kekchi rows have, however, produced more plants, and more of these have grown to maturity than with any of the domestic or foreign varieties included in the test. The Kekchi type has also remained more constant in Maryland than did the King variety when grown in Guatemala, though there are obvious differences between individual plants. Two plants in particular were found to have numerous buds, some ready to blossom before any of the others had begun to show signs of productive maturity.

It might be feared that a variety newly introduced from a tropical country would be likely to suffer more from low temperatures than our United States varieties, but this seems not to be the case with the Kekchi cotton, even when the cold is carried down to the freezing point. There were light frosts in Lanham about the end of September, just sufficient, as it happened, to do appreciable damage to cotton in low ground. The Kekchi plants did not suffer more than the American Upland varieties. The difference, if any, was in favor of the Kekchi cotton, perhaps on account of the closer foliage.

Many annual plants, even those of tropical origin, are most vigorous and productive at their northern limits of growth, not, as has been supposed, because this is the coldest part of their range, but because the heat and sunlight, necessary to plant growth, are greater during our summer months than can be secured in a similar time in the Tropics, owing to the much longer days of our northern latitudes.[a]

The Pachon cotton from western Guatemala, though it has grown taller at Victoria, Tex. (52–79 inches), than at Lanham, Md. (30–40 inches), has produced numerous buds in Maryland, but none in Texas. The Kekchi cotton also appears to have been more productive at Lanham than at Victoria, to judge from a recent partial report from Mr. Argyle McLachlan.

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[a] Cook, O. F., 1902. Agriculture in the Tropical Islands of the United States, Yearbook of the United States Department of Agriculture for 1901, p. 367.

It is very possible, therefore, that if the Guatemalan variety is able to thrive in the United States it will ripen its crop here in even less time than it requires in Guatemala, and this is rendered the more probable from the fact that in Guatemala the cotton has to be planted in the rainy season and is obliged to exist for the first few months under conditions of excessive moisture. The dry season of this district is short and uncertain. For two years, 1903 and 1904, the Indians were unable to burn their clearings, so that the corn crop failed and the community was reduced to the verge of starvation. The cotton crop, in normal seasons, is said to be planted in the latter half of October and ripens in March.

The introduction of a dwarf, short-season cotton would require, of course, something of a change in cultural methods in the South, since the smaller size of the plants will need to be compensated by closer planting. It will be readily understood that to secure the setting of a crop in the minimum of time as many plants as possible should be set at work. The question is not that of the maximum product for each plant or for a given area. With the weevil in the field the time factor becomes of chief importance.

Little is gained in reality by the rank growth of the larger varieties; in fact there is a distinct loss in earliness, even though some bolls are set in the early part of the season. If these are overshadowed and starved by the continued upward growth, the crop is delayed and the lower part of the plant becomes, on the whole, distinctly unproductive.

EARLY BEARING FACILITATED BY LONG BASAL BRANCHES.

The earliness of the Kekchi cotton is made possible by the fact that the bolls are nearly all borne at the base of the plant, the upper branches and their foliage serving merely to assist in bringing to maturity the fruits which are set while the plant is still very young.

Like several other tropical economic species, such as coffee, cacao, and the Central American rubber tree, the cotton plant has two kinds of branches—the true or primary branch, which arises in the normal position of branches in the axil of the leaf, and the secondary or fruit branches, one of which arises at the side of each primary branch. In most varieties only a few of the true branches are developed; often none at all. They are almost always plainly indicated, however, by a small bud or a stunted leaf or two, in case the bud has not remained entirely dormant.

Cotton plants are either right-handed or left-handed in the sense that on the same plant all the secondary branches come out on the same side of the primary branches. It is possible, therefore, to determine by its position whether any particular branch is a primary or

a secondary. But the function of the two sorts of branches does not always remain as distinct as in the coffee and cacao. A primary branch, like the main stem, never bears any flowers; it produces only leaves and other branches, mostly secondary.

Secondary branches, on the other hand, produce normally a flower bud at the axil of each leaf, and this rule holds very generally, except that at the lower part of the plant it sometimes happens that a branch which has the secondary position functions as a primary; that is, instead of bearing buds and flowers it produces only leaves and secondary branches. In the Kekchi cotton, as grown crowded together in the Indian fields, the primary branches seldom appear, but when more space is allowed and the soil is fertile it is usual for two branches to start from the axil of each of the lower leaves, one promptly producing flowers, the other assisting in the rapid increase of the leaf surface of the plant and of its power to elaborate food.

Under the popular idea that plants draw their food from the ground the possession of branches which bear little or no fruit might be looked upon as an undesirable character, but when we take into consideration the fact that the leaves instead of the roots are the true assimilating organs of the plant it becomes apparent that a variety of cotton which develops its lower primary branches may have an advantage in earliness over one which is obliged to depend for its foliage upon secondary or fruit-bearing branches. In the matter of determinate habits of growth these primary branches are also a feature, because they enable a plant to produce a full quota of leaves without unduly increasing the number of fruiting branches and thus continuing to add to the number of superfluous buds.

The most obvious characteristic of the Kekchi cotton as it grows in our experimental plots is the long basal branches, which often equal or exceed in length the main stem itself. The most prolific branches of the United States varieties are those which come out from the main stem at the height of about a foot, but the bulk of the crop on the Kekchi cotton is borne much closer to the ground. (Pl. II, fig. 2.) The long basal branches facilitate the early ripening of a uniform crop of cotton, but they will not be an advantage under all circumstances; as, for example, in dry regions where the weevil can be held in check by open culture. The necessary exposure of the fallen squares to the full sunlight on hot, dry soil would be interfered with by a plant of low spreading habit and dense foliage.

EARLY REJECTION OF SUPERFLUOUS SQUARES.

That the Kekchi cotton has a limited or determinate growth and does not take advantage of the perpetual summer to become a tree or even a large bush is evident from the fact that in the latter part of

the season most of the flower buds and leaf buds blast and fall off while still very young, before the weevil would give attention to them. By the time the first of the cotton is beginning to ripen, most of the plants have ceased flowering and no new leaves are being put forth. Generally there are bolls only near the base of the plant.

It is a normal character of the cotton plant that the fruiting branches shall produce a bud at each node or joint; that is, at the base of each leaf. If all these buds were to be retained and treated impartially to the food materials which the plant is able to supply, the result would undoubtedly be disastrous, since the plant would be able to bring very few of its fruits to maturity, perhaps none at all, unless a part of the burden were removed by the weevils or by other outside causes.[a] It is under the necessity of throwing off a part of its load of fruit at one stage or another of its development, the younger the better.

The rejection is accomplished by the formation at the base of the peduncle, or fruit stalk, of special layers of cells of soft texture, which soon disintegrate and allow the bud or young fruit to fall off. This is one of the many instances of the prodigality of nature, which makes so many allowances in advance for the accidents which beset the existence of all living things. The waste of buds is, perhaps, not so large in proportion among the perennial "tree" cottons, which form a considerable shrub before beginning to blossom. In cultivation, however, the tendency has always been to encourage early bearing, and thus reduce the early vegetative period of the plant and bring it to a precocious maturity. The result is that fruiting branches are produced, even on young plants, and buds are formed out of all true proportion to the actual productive power.

The habit of rejecting a large part of the squares and bolls is especially obvious in the "cluster cottons," varieties in which the branches are abnormally shortened, so that the leaf surface of the plant is still further reduced. This cuts down still more the productive power of the individual plant, though there may be a gain in the number which can be grown on a given area.

But cluster cottons have not learned to moderate their promises to correspond with their powers of performance, and continue to set vast numbers of buds, flowers, and bolls, which they are unable to ripen. The same is true to a less obvious extent of all our Upland varieties, but until the advent of the boll weevil the superfluous buds were not a serious factor, and the waste under favorable conditions was often well compensated by the power to recover and set a new

[a] In Texas it is believed that rain at the time of flowering reduces the crop to half the normal quantity, or even less. The explanation given is that water settles in the flowers and prevents fertilization. This might serve as an additional indication that cotton originated in a dry climate.

crop when in unfavorable seasons the earlier buds were lost, or when, as occasionally happened in southern Texas, there was a liberal top crop, or second period of bearing, late in the autumn months.

The presence of the weevil alters all these factors. The superfluous buds become positively detrimental, for they furnish the breeding grounds for successive generations of weevils and enable the pest to attain in the latter half of the season such numbers that a top crop not only becomes utterly impossible, but a menace is prepared for the cotton of the following year. For, although only a small proportion of the weevils live through the winter, the number of survivors undoubtedly has a very practical relation to the supply maintained at the end of the previous season, and this again is merely a question of this persistent production of buds, now much worse than useless.

A short-season variety of cotton having a sufficiently determinate habit of growth would by itself constitute a solution of the weevil problem. The Department's entomological investigations in Texas indicate that it is only the weevils hatched in the last month of the growing season—in October or November—which have a prospect of surviving the winter. A cotton which ceased to produce buds after July or August would remove the chance of wintering over from all the weevils except the few that might develop in the bolls, an almost infinitesimal number compared with those that now attain maturity in the squares. Much would be gained, of course, if all planters would promptly pick their cotton and then pull up and destroy the plants, being especially careful to collect the infested bolls. But to carry out efficiently such a programme is difficult and expensive.

To what extent, if any, the Kekchi cotton will meet this need of a short-season determinate variety, it is too early to form an opinion, but the fact that it has these qualities to a higher degree than any of the varieties hitherto known in the United States must be accepted as evidence, at least, that the possibilities of this method of protection have not been realized. In the latter part of the season the Kekchi cotton ceases the upward growth of the main stem and its branches and regularly drops the greater part of its buds before they are large enough to be entered or fed upon by the weevils, and the analogies to be drawn from the habits of other plants will justify persistent efforts toward the development in this and in other stocks of the habit of rejecting the buds still earlier or of not forming them at all after the first crop of fruits has set. Many plants have, in fact, exactly this habit so desirable in cotton; they continue to flower until permitted to set seed.

SEASONAL BEARING OF PERENNIAL VARIETIES.

The continued existence of perennial cottons in weevil-infested countries, like Guatemala, proves the presence in these also of means of protection. One of the most important is, doubtless, the production of an annual crop at a definite season, leaving the weevils without opportunity to breed in the intervening months, thus greatly reducing their numbers.

The popular impression that tropical plants take advantage of the continuous summer climate and blossom continuously is correct only for a small minority. Where there are definite wet and dry seasons many tropical plants have alternating periods of growth and rest almost as pronounced as in temperate climates, and even in regions of continuous humidity there are some species which shed their leaves annually and rest for a time.

A further general reason for a simultaneous annual blossoming of all the flowers of a species is undoubtedly to be found in the greatly increased opportunities of cross-fertilization, just as many insects swarm and many birds and mammals collect in flocks before the breeding season. Simultaneous flowering is carried to a remarkable extreme among the bamboos, where whole species grow for long series of years without flowering, and then flower and die at once over long distances and in spite of local diversity of conditions which might be expected to advance or retard maturity.

Accordingly, while it would not be reasonable to insist that perennial varieties of cotton have adopted the habit of annual flowering only because of the boll weevil, the analogy of other plants may be invoked to show that such a character can be brought about by selective influence. The weevil could certainly assist in the development of such a tendency, especially if there were a season of the year in which the insects were less numerous, from climatic or other external causes as yet unknown.

The tropical varieties of cotton are, as is well known, mostly perennial, and some of them develop into trees of considerable size, the trunk attaining a diameter of 6 or 8 inches, and the main branches a length of 15 or 20 feet. The existence in Mexico of tree cotton immune to the weevils has been reported, but as yet this has not been substantiated. Possibly the weevil has not yet penetrated some of the remote and arid parts of the republic. In eastern Guatemala, at least, the tree cottons appear to enjoy no immunity from the weevil, and at the time of the visit of the writer it was often impossible to secure uninjured bolls, even as samples of the varieties. The native cottons of the island of Cuba, according to Mr. E. A. Schwarz, also have the habit of annual blossoming, in the intervals of which the number of the weevils becomes greatly reduced. The cutting back

of the cotton by the Indians at Rabinal, as described in the next paragraph, is an artificial means of attaining the same end, but the native Sea Island cotton, found at San Lucas, and the Kidney cotton, at Tucuru, are the best Guatemalan examples of this protective habit.

ANNUAL CUTTING BACK OF PERENNIAL VARIETIES.

While the annual variety of cotton protected by the keleps is the basis of the only field culture found in eastern Guatemala, the Indian population of the central plateau about Salama and Rabinal raise small quantities of cotton in their dooryards by means of another cultural expedient, apparently of great antiquity, as indicated by the extent to which the plant is adapted to the cultural conditions. The variety is perennial and has very small and inactive nectaries, possibly as an adaptive result of the dryness of the climate.

Most of the perennial varieties begin bearing only after the plants have attained considerable size, but the Rabinal cotton is a notable exception to this rule and avoids injury from weevils by the very prompt flowering and fruiting of the new shoots.

The weevils are present in numbers, and are frequently seen crawling about on the plants in a leisurely manner quite different from that which they affect in regions stocked with keleps. At the time of our visit not a single boll or bud of any except the smallest size could be found which had not been attacked by them. Nevertheless, a crop of cotton is secured at another season. In the month of April the Indians cut back all the bushes to the ground, and as the cotton is always planted immediately about the doors of their houses, where the chickens and turkeys congregate, the mortality of weevils at this time is probably very great. The protection of the domestic birds doubtless continues until the new shoots have grown out of reach.

As soon as the plants are a few inches high they begin flowering, and before the weevils are sufficiently increased in numbers to become injurious a crop has been set. Flowers and fruit are commonly borne on the lower branches, only 6 or 8 inches from the ground. The Indians say that if the cotton is not cut back, but allowed to grow tall, they get no crop. The fact is that by that time the weevils are too numerous to permit normal bolls to be formed. Our search for such was quite in vain on both our visits to Rabinal. One boll which gave no certain external proof of injury was wrapped up in a paper and retained as a sample, but was overlooked in packing and not transferred to the preserving fluid. When the paper was unwrapped a few weeks later three dead boll weevils were found.

The Rabinal cotton crop is evidently not large, but the harvest is said to be regular, and the area of fertile land in this district is so small that none of it is wasted. Much foreign thread is now

imported, however, for weaving in the native looms. The industry has greatly declined in the last century, perhaps because chickens have been generally substituted for turkeys, which were formerly the only domestic fowl possessed by the Indians.

All attempts at establishing field cultures of cotton in this region have failed. The local public, which does not take the weevil factor into consideration, is firmly persuaded that cotton will not bear except in the heavy, rich soil of the dooryards of the Indian villages.

HAIRY STALKS AND LEAF STEMS.

The weevil on foot is a rather slow-moving, clumsy insect, and it has been ascertained in the course of the investigations conducted by Messrs. Hunter and Hinds that its movements on the plants are to a great extent impeded by hairy stalks and leaf stems. The smooth Egyptian and Sea Island varieties were found to be more susceptible to weevil injuries than the hairy Upland sorts. The Kekchi cotton is still more hairy, however, than the United States varieties, and gains an added advantage from this fact.[a] The longer it takes the weevils to climb from one bud to another the greater are the chances of their being caught by the keleps. The latter insects, owing to their much longer legs and the claws with which their feet are armed, are not only able to travel readily over the hairs, but find them of definite assistance. On smooth surfaces they are much less adroit in catching and stinging the boll weevils. In our experiments, too, they seemed to prefer the hairy Upland cottons to the smooth Sea Island varieties.

The difference between the two insects in this respect may also be illustrated by the fact that the keleps are unable to ascend a perpendicular surface of clean glass, a feat which the weevils accomplish without difficulty.

That the Guatemalan cotton was more attractive to the keleps than the United States Upland and Sea Island varieties planted in adjacent rows seems to be indicated by a census of our plot experiment, taken April 19 by Mr. Argyle McLachlan. Kelep nests were found at the bases of 41 per cent of the plants of the other varieties,

[a] Though distinctly hairier than our ordinary Upland varieties, the Kekchi cotton is exceeded in this respect by two other Guatemalan types, as well shown in a field test at Lanham, Md. The Pachon cotton obtained by Mr. William R. Maxon in the Retalhuleu district of western Guatemala is distinctly more hairy than the Kekchi variety, though it seems to be lacking in other weevil-resisting features. The involucral bracts are not closed any more than in the Sea Island or Egyptian types. The most hairy cotton of all is the Rabinal variety, at least in the form it has taken at Lanham. The plants are very much more robust in every respect than at home in Guatemala, and the hairy covering shares in this increased vigor.

while 76 per cent of the plants of the Kekchi cotton were favored with kelep nests. This apparent preference may be somewhat exaggerated, perhaps, in view of the fact that the plants were often farther apart in the rows of the Kekchi cotton, the seed having germinated very irregularly. Moreover, the superior attraction of the Kekchi cotton for the keleps may not have consisted entirely in the greater hairiness or the more abundant nectar. The compact foliage and spreading lower branches of the Kekchi cotton give greater protection from the midday sun, which the keleps utilize by greater activity in the middle of the day.

With the Sea Island varieties it seemed obvious, however, that the smooth stems, more open habit, and smaller supply of nectar result in distinctly less attention from the keleps. From 9 or 10 o'clock on hot days they foraged very little, and seemed to have quite disappeared from these varieties, though still to be found in considerable numbers on the stems of the Upland varieties and most of all on the Kekchi cotton, which appears especially adapted for the comfort and convenience of the keleps.

It was noticed, however, that the keleps went much more often into the involucres of the Sea Island and Egyptian varieties than into those of the Kekchi cotton, for the simple reason, probably, that they can get in more easily.

In the latter part of the season, after the weevils had gained a footing in this field, Professor Pittier noticed a very decided preference on their part for the Egyptian varieties, though it seems certain that this type of cotton had never been planted in the country before. The partiality of the weevils might be explained, perhaps, on such grounds as the relative absence of the keleps, and also the ease of access to the buds of the Egyptian cotton allowed by the more open involucres. However, a slight change of food or of conditions of growth is often a distinct advantage to plants and animals, so that a direct preference for a new variety as food might reasonably be expected, and similar instances are known.

The greater hairiness of the stems and the presence of the keleps may also explain why the weevils in Guatemala were seldom seen walking about on the cotton plants as they do in Texas. On the other hand, they take to wing very readily and seem to prefer to alight in the open flowers, the only places on the cotton plants where they are safe from the keleps.

The petals are so smooth that the keleps seldom descend into the flowers, and when they do sometimes appear to be unable to climb out. The petals of the Sea Island sorts are smooth even on the margins, sometimes entirely so, while those of the Upland varieties are fringed with fine hairs well up on the sides, if not all the way round the apex.

The liability to capture by such an insect as the kelep may also afford an explanation of the peculiar sedentary habits of the male weevils, which often remain stationary in one involucre for long periods, or as long as their food supply lasts. It is necessary for the females to go about in search of fresh squares for egg laying, but similarly active habits on the part of the males would subject them to unnecessary danger.

PENDENT BOLLS.

The early bearing of the Kekchi cotton is made possible, as already noted, by the unusual development of the lower lateral branches, which often have a drooping habit, leaving the buds and bolls in pendent position, intead of upright. There are several advantages in this arrangement, one being that the instinct of the weevils leads them to the upper portion of the plant. In a very badly infested field without kelep protection, the only bolls which escaped the weevils were a few lying close to the ground on these lower pendent branches of the Kekchi cotton. Only at the time of flowering does the peduncle curve upward and give the flower its normal upright position. Thus these drooping lateral branches of the cotton, which seem to hide the buds and bolls away from the weevil, may be looked upon as a short step in the direction of such phenomena as the cleistogamous flowers of violets which remain buried in the ground, or those of the peanut which, after flowering, burrow into the soil to ripen their seeds.

The flowers of the cotton plant open in a more or less directly upright position, and this is retained by the boll in most varieties. In the so-called "stormproof" sorts, however, the bolls hang down, and this is looked upon by many planters as a distinct advantage, since when the boll is ripe and open the rain does not beat into it and wet the cotton or wash it out, but is shed by the protecting outer shell and involucre.

On pendent bolls the external nectaries are brought upward, so that there is no danger of an abundant secretion of nectar being lost by dropping off. The surface of the nectary is papillate and has a somewhat waxy appearance. The secretion often collects as a distinct drop. The nectaries are also more readily visited by the keleps, and the young bolls are likely to be better protected by them. If these remained upright, the weevils would be more likely to alight and enter the involucre at once.

The drooping habit may have a mechanical explanation as the result of the weakness of the comparatively slender lateral branches. It is also to be connected, perhaps, with the habit of early flowering and fruiting, since this would bring heavier bolls upon smaller and softer branches which would be twisted over by their weight. In

the later and more upright varieties the flowers are not formed until the wood of the branches has hardened and become strong and rigid. Pendent bolls may thus be said to be incompatible with the cluster habit, which is brought about by the abnormal shortening and thickening of the lateral branches, which are able to hold their flowers and fruits rigidly upright, except as they may be turned sidewise by being crowded together. The cluster cottons, too, have the undesirable tendency to an abnormal multiplication of squares and young bolls, many more than the restricted leaf surface of the plant will enable it to ripen. This superabundance of flowers and fruits gives, however, the greater encouragement to the weevil, and uses up vegetative energy which could be better employed in the prompt ripening of the bolls already set. It is no uncommon thing, however, for even half-sized bolls of cluster cottons to die without any sign of external injury or disease, while other varieties close by remain perfectly healthy. The cause is probably to be found in inadequate nutrition, but this might also be expected to give them increased susceptibility to injury from parasitic enemies of every kind.

It is not unlikely, too, that the drooping habit may be connected with the greater size of the inside nectaries of the Guatemalan variety. These are, as far as we have seen, larger than in any other American variety yet known; but the Asiatic cottons, which have the inside nectaries still larger and more active, are also more definitely pendent. The involucre is grown together at the base, as though to more thoroughly protect the nectaries from above—from the sun, which would dry up the secretion, and from the rain, which would wash it off.

The nectar is formed in great abundance, and Mr. F. J. Tyler, of this Department, has called attention to the fact that the surface of the nectaries of the Asiatic cottons, instead of being merely papillate, as in the American Upland varieties, has a covering of close-standing fine hairs, to which its velvety appearance is due.

Finally, it may be remarked that for cotton with upright bolls the inside nectaries are often an element of danger, since when the secretion is abundant and is not removed it flows along the bases of the involucre and may serve as a medium for the germination of parasitic fungi or bacteria. Bolls are not infrequently found diseased around the base, apparently from this cause.

EXTRAFLORAL NECTARIES.

The cotton plant is not without floral nectaries similar to those of related genera, consisting of fringes of nectar-secreting hairs lining the pits inclosed between the bases of the petals. The nectar serves, doubtless, the same purpose as in other plants, the attraction of the

honey-loving insects through which cross-fertilization is secured. It does not appear, however, that the floral nectaries of the cotton have any connection with the problem of weevil resistance, although the weevils seem in Guatemala to spend a considerable part of their time in the flowers, which are indeed the only safe places for them on plants protected by the keleps. It had been noticed from the first that the keleps seldom visit the cotton flowers, and Mr. Kinsler has learned a very adequate explanation of this fact, namely, that they are able to climb out of the flowers only with considerable difficulty, and sometimes remain imprisoned in spite of all their efforts to escape.

The functions of the extrafloral nectaries of plants are, as far as can be ascertained, similar to those of the floral nectaries to the extent that they attract insects, but beyond this there is a fundamental difference; the floral nectaries and highly colored floral organs serve to secure visits of flying insects and thus maintain intercommunication and cross-fertilization between the different members of the same species, in spite of the fact that the individual plants are rooted fast in the ground. The extrafloral nectaries, on the other hand, attract to the plants insects which will remain upon them as permanent residents, and this is the end secured by the extrafloral nectaries of the cotton.

It may be objected by some that no use or benefit to the plant has been ascertained in the case of many species which have extrafloral nectaries and other insect-attracting devices. Much remains to be learned concerning these marvelous biological specializations, and there are two obvious alternatives which need to be canvassed before belief in the adaptive nature of extrafloral nectaries and analogous structures can be destroyed. The character and extent of many such specializations show that they have existed for a long time. They may have served protective purposes no longer apparent. The other consideration is that some of the symbiotic specializations existing between such plants as Cecropia and Acacia and their insect inhabitants have arisen through selective encouragement, much as the special characters of our domestic plants and animals have been developed. It may be sufficient, in other words, that the nectaries or other structures be of use to the insects which have done the selecting. It may seem absurd to think of bushes or trees as having been domesticated by ants many thousands of years ago, but the wonder is no greater than that ants and termites regularly maintained subterranean fungus gardens ages before mushroom culture was undertaken by man.

NECTARIES OF THE LEAVES.

The midrib of each leaf bears on the under side an oblong pit, from which a drop of nectar may often be seen to exude. This is collected and eaten by the keleps, which are thus induced to visit all parts of the plants, especially while they are still small.

The habit of collecting the nectar was not previously known to exist among the insects of the family (Poneridæ) to which the kelep has been referred. Nevertheless, the fact is not open to question. The process is easy of observation in even greater detail than with the true ants or the bees, because the keleps do not, like these insects, have the art of regurgitating their food. They merely lap the nectar up to form a drop, which, protected by the widely opened mandibles, is carried into the nest to feed the queen and the young.

Nectaries, or at least nectary-like depressions, are to be found probably on the leaves of all varieties of cotton, though very small and apparently inactive on some of the larger tree sorts.[a] The shape of the nectaries also varies greatly in the different species and varieties, some being longitudinal, others transverse, and still others crescentic or even sagittate. Some varieties have nectaries on the three principal veins, and some even on five veins.

The leaf nectaries of the Kekchi cotton are to be found on the midrib of the leaf about 1.5 cm. from the base. They consist of a rather shallow longitudinally oval depression surrounded by a broad raised rim. The midrib often appears distinctly narrower above the depression than below it, as though there were extra tissues to supply it. The secretion is quite active, nearly all the nectaries showing a small amount of liquid, which sometimes spreads out on the adjacent surfaces.

These nectaries furnish, as might be expected, a medium favorable for the growth of molds or fungi, and there is often a considerable network of dark-colored fungus mycelium creeping in and about the moistened depressions, and with occasional erect, needlelike points, which may be fruiting bodies.

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[a] This was not true, however, of a Mexican "tree cotton" of the Upland type grown in the Department's experimental plots in Texas last year. Large nectaries were generally present on three veins of each leaf, and the midvein often had two. They were of the crescentic or sagittate type, but often extremely long and distorted. Another Mexican tree cotton, with a different type of lighter green foliage, suggesting that of Bixa, had nectaries only on the midvein and these reduced to a narrow groove. The vein was not thickened nor the margins raised. The two varieties were about as different as could well be with respect to nectaries. Neither produced either flowers or fruit, so that their true relationships were not to be ascertained.

EXTERNAL NECTARIES OF THE INVOLUCRE.

The Guatemalan cotton protected by the keleps has three broadly oval or reniform pits at the base of the involucre, one at the middle of the base of each of the involucral leaves.[a] These are larger, deeper, and more active than the nectaries of any of the Texas varieties as yet observed, though there is very great diversity of size and nectar-secreting activity. In some of the varieties these nectaries are reduced to mere rudiments or are entirely wanting. The depression may be present, but with no secreting tissue. The variety nearest approaching the Guatemalan cotton in having large and active nectaries is the Redshank, but the King and other related sorts also have fairly large nectaries.

The drooping or pendent position of the bolls in the Kekchi cotton may be correlated with the special development of these nectaries, as already noted. In the middle of the day the keleps are not very active, but the nectaries are sometimes full to overflowing. If the bolls kept the erect position usual in the varieties cultivated in the United States the nectar would frequently drop off and be lost, but when the fruits hang down the cuplike nectaries are brought uppermost and hold the liquid much longer.

The evolutionary origin of these nectaries is fairly obvious. The bracts are to be looked upon merely as modified leaves, with nectaries which have increased in size and activity as the leaves have become smaller and more specialized.

INNER NECTARIES OF THE INVOLUCRE.

As though to induce the keleps to come inside the involucre and thus more effectually protect the young buds and bolls against the weevil, the Guatemalan cotton is also provided with unusually large interior nectaries, alternating in position with those of the outer series and thus placed opposite the edges of the involucral leaves or bracts. These inside nectaries, like the outside ones, are larger and more active than those on most of the cottons cultivated in the Southern States, but the closing of the involucre and the devolopment of the inside nectaries have been carried much farther in the Old World cottons belonging to the species *Gossypium herbaceum*. Here the external nectaries are quite wanting, but the internal ones are enormously larger and heartshaped, and secrete nectar in such quantities that it often flows out in the groove between the adnate

[a] Instances are occasionally found where only two nectaries are developed, but such deficiencies are much less frequent than in other varieties of the Upland and Sea Island series. The Rabinal cotton commonly has only two external nectaries. The Old World cottons thus far observed have no nectaries in this position.

bracts to moisten the edges of the involucre. As yet, however, the purpose of these adaptations in the Asiatic cottons is entirely unknown, both the boll weevil and the kelep being absent in the Eastern Hemisphere.

The botanical homology of the inner nectaries is somewhat different from that of the outer. They correspond in all probability with the nectaries which are found on the calyx of some of the species of Hibiscus, but there the calyx is large and covers the buds and each sepal bears a nectary near its middle.

NECTARIES OF GUATEMALAN SEA ISLAND COTTON.

A variety of Kidney cotton planted in small quantities by the Indians at Trece Aguas, Guatemala, has the outer nectaries very variable in size and commonly quite wanting.[a] The inside nectaries seem always to be developed and are unusually large, being exceeded, as far as known, only by those of the Asiatic varieties. The nectar secretion is also very abundant. No weevils were found upon this cotton, nor any keleps.

On the other hand, the free-seeded Sea Island cotton found by Mr. Kinsler in the San Lucas[b] neighborhood, not far from the kelep cotton culture of Secanquim, reverses again the tendency of the Kidney cotton to the great development of the inner nectaries and the suppression of the outer. The latter are, in the San Lucas cotton, nearly always present, of rather large size, and of a red color. The inner nectaries are often rudimentary or quite absent.

CONTINUED SECRETION OF NECTAR.

Our Upland varieties commonly secrete nectar only at the time of flowering, but in the Kekchi cotton the liquid continues to exude until the boll is nearly or quite full grown, thus securing the protec-

[a] This variety not infrequently produces flowers with only two bracts, closely appressed, like a clam shell. In one such instance there were two nectaries at the base of each bract, or, to be more exact, two separate nectaries on one side and one partly divided nectary on the other, as though the nectary belonging to the deficient third bract had separated into two parts and joined the other nectaries.

[b] This San Lucas Sea Island cotton is probably the variety in which the weevils were found abundant in 1902, when the first intimation was gained that the Kekchi cotton had means of protection against the weevil. The San Lucas cotton is attacked not only by weevils, but by another long-bodied insect larva, evidently lepidopterous, that gnaws through the boll at the ends, both from above and below, and eats out the seeds. Nothing of the sort has been seen in the fields protected by the keleps. There was also noticed in this cotton an occasional abnormality closely comparable to the navel orange. Rudimentary parts like a small secondary boll were found in the middle of bolls otherwise normal. The orange tree and the cotton plant belong, it may be remembered, to related families.

tion of the keleps for a longer period. The temporary character of the secretion in our United States sorts was reported by Professor Trelease several years ago.

In Guatemala, however, the young bolls seem to be quite as efficient as the flowers. It is even possible that this generosity on the part of the plant is excessive, since if the number of keleps is small they may find all the nectar they need on the lower bolls, and hence have less inducement to inspect other parts of the plant. Under favorable conditions in Texas the cotton plant produces a much larger number of flowers than in Guatemala, so that what is lacking in quantity may be made up by numbers, in case it should become possible to utilize the keleps in Texas.

RACTLETS SUBTENDING INNER NECTARIES.

The Kekchi cotton is distinguished from all our Upland and Sea Island types by the more regular presence and much larger size of a series of bractlets, a pair of which usually subtends each of the inner nectaries. In other varieties these are either wanting entirely or are rare and rudimentary.[a] The bractlets are inserted somewhat obliquely, with their margins in contact below the nectary.

Sometimes they serve to conduct nectar to the edge of the involucral bracts, the nectar following along between the slender bractlets like ink between the nibs of a pen, as though to coax the keleps inside the involucre. This must happen rather infrequently, however, to judge from the great irregularity in the size of the bractlets. Sometimes they are half an inch or more long, and extend well into the angles of the involucre, or even project outside. (Pl. III.) Nevertheless, it

[a] Professor Trelease, who studied the American Upland varieties, appears not to have found the bractlets in pairs. He says: "These glands (the inner nectaries) belong in reality to an inner whorl of three bracts, alternating with the outer ones, but generally wanting. In stunted plants, especially as cold weather comes on, one or more of these inner bracts may be found." (See Comstock, 1875, Report upon Cotton Insects, 324.)

The shape and position of the bractlets seem to warrant the suggestion that they represent the stipules of the outer bracts instead of an independent inner whorl of bract leaves which has first become specialized and then become rudimentary. The suggestion has the further warrant in that it may help to explain the numerous involucral appendages of some of the related plants, which range about the number 9—that is, 3 leaves and 6 stipules. The normal number should be 6, if the two whorls of leaves were represented. One of the Guatemalan species of Hibiscus examined with this interpretation in mind seemed to confirm it by showing very often 3 of the appendages broader than the others, though the total number varied from 8 to 11, with an irregularity quite comparable to that of the bractlets of the cotton. Even the bracts of the cotton sometimes vary, involucres of 2 bracts being found occasionally, and in rare instances 4.

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may well be questioned whether these inner bractlets have remaine unusually large in the Kekchi cotton because they have a definit function or because of the greater size and activity of the adjacer nectaries.

A variety of cotton called Pachon, planted rather extensively in tl Retalhuleu district of western Guatemala, and likewise protected t the keleps, is similar to the Kekchi cotton in many respects, includin the possession of these large stipular bracts subtending the inn nectaries, but with the addition that the bracts are fringed with lon hairs, as though to hold the nectar the better. This may also be tl function of the hairs which cover the nectaries of the Old Worl cottons

EFFICIENCY OF THE KELEP PROTECTION.

The special development of the extrafloral nectaries in the Kekcl cotton has been noted in former reports, it being the nectaries whic attract the keleps to the cotton plant. That the kelep preys upon bo weevils and protects the cotton crop was learned last year, but it w still possible to question the practical value of this form of defens Such doubts would not have survived an inspection of our recer experiments in Guatemala. A small field of cotton just outside tl kelep area was attacked by the weevils in such numbers that not single normal boll developed on any of the United States Upland an Sea Island varieties. In the field protected by the keleps the weevi obtained no footing until the plants were well grown and an excelle crop of full-sized bolls had been developed.

To test the efficiency of the keleps as destroyers of boll weevils an as protectors of cotton would be possible in Texas only by stocking large area with keleps—a difficult and expensive undertaking. N small tract would give a fair indication, since the weevils from tl whole neighborhood would continue to come in, and, although the might soon be captured, would be able to do vastly more damage tha would be possible if the whole region were stocked with keleps.

In Guatemala, however, it was quite possible to contrast a protecte with an unprotected piece of cotton by the simple expedient of plan ing outside the area occupied by the keleps. A more striking resu could hardly be imagined. For several weeks, during which the tw plots were under continuous observation, the one remained almo entirely free from weevils and weevil injuries and set an excelle crop, while in the other scarcely a flower opened or a boll develope The very few exceptions were on the concealed drooping branches o the native Kekchi cotton.

The weevils became, indeed, too numerous for their own prosperit and fed upon and destroyed the very young buds before they wer old enough to breed larvæ. Twenty-five fallen squares collected an

examined from under the plants of the plot without keleps yielded only 6 larvæ, or 24 per cent. They even attacked the young leaf buds, as observed last year at Rabinal.

A large proportion of the injuries were caused by feeding punctures, but this only emphasizes the fact that the number of weevils which migrated into this plot was sufficient for a complete destruction of the crop, and since the other experiment protected by the keleps was much nearer to the fields of the Indians there is every probability that the weevils would have been, if possible, even more numerous if the keleps had not been at hand to catch them.

The unprotected plot was located at about one-quarter of a mile outside of the belt of Indian cotton culture, on land not inhabited by keleps. The weevils lost no time in finding the new field. Infestation was complete, and quite as destructive as in Texas, the weevils being so numerous as to overcome whatever resistance the cotton might have been able to oppose to smaller numbers of the pests. The Sea Island, Egyptian, and United States Upland varieties were not permitted to produce flowers or even full-sized buds, and even the native Guatemalan varieties shed their squares before the persistent onslaughts of the weevils.

Cotton is regularly cultivated by the Indians in this immediate neighborhood, and Indian plantings more or less infested with weevils were to be found within short distances of the protected field. Nevertheless, the keleps proved to be sufficiently abundant on this piece of ground to completely exclude the weevils. There were enough, indeed, to protect with apparent impartiality all the kinds of cotton included in the experiment, but if the numbers had been less and the plants had been closer together, as in the Indian fields, we may be sure that those producing the most nectar would have received the most protection from the keleps.

The weevils were seldom to be found in the plot stocked with keleps as long as the Indian cotton remained in vigorous growing condition, but about the time the Indian cotton ripened, the weevils seemed to make a more determined raid on our field, and along one side nearly every plant suffered somewhat, though the weevils could rarely be found except in the open flowers, which seem to be recognized as their only safe roosting places. In a week or ten days there was a distinct falling off, so that very little damage was being done, and there was another short interval of practically complete protection. But after this a renewed onslaught began and the numbers of weevils gradually increased, the Upland and Sea Island plants continuing to produce thousands of new squares in which the weevils were able to breed, quite as in the United States.

That the keleps are definitely attracted to the cotton plants, as stated in previous reports, is fully demonstrated by the fact that

many of the colonies moved their nests to new burrows excavated immediately at the bases of the cotton plants. In some parts of the field the proportion of cotton plants having kelep nests established about their roots reached nearly 75 per cent, whereas the chance that the positions of the cotton plants which stood in regular rows would coincide with those of kelep nests would not be one in hundreds.

The success of this experiment would seem to justify fully the suggestions made in connection with the first announcement of the discovery of weevil-resisting adaptations of the cotton plant, namely, that the protection which these Central American varieties had been able to secure from the kelep had afforded them an opportunity, perhaps unique, of developing other resisting adaptations. The Kekchi and other related cottons, though having no monopoly of weevil-resisting characters, furnish, however, the only instance as yet known to scientific observation in which a field culture of cotton has been maintained for long periods of time under climatic conditions favorable to the boll weevil.

In Central America, at least, the secretion of nectar by the cotton is not a useless or meaningless function, as observers of the plant in other parts of the world have sometimes supposed. The cotton is not the only plant upon which the kelep can live, nor the boll weevil the only insect upon which it preys. To secure the attention and obvious preference of the kelep the cotton has been obliged to put forth the superior attractions provided by its numerous extrafloral nectaries.

This additional proof of the value and efficiency of the kelep does not affect, of course, the possibility of acclimatizing it in the United States. A more extended search in Guatemala resulted in finding the insects under a wide range of conditions, and at altitudes of from 200 to 2,000 feet. It lives and thrives, moreover, in soils very much drier than those to which it was supposed last year to be confined. Last year's experiments in Texas indicated likewise that the kelep withstands drought much better than it does standing water in its burrows, and care is being taken this season to locate colonies with a view to adequate drainage.

OTHER NECTAR-BEARING PLANTS VISITED BY THE KELEPS.

The honey-collecting habits of the keleps are not confined to the cotton. Another favorite is a species of Bidens (*B. pilosa*) called by the Indians "tshubai," which has considerable value as a forage plant, being of quick growth and succulent texture.

The preference of the kelep for the tshubai as a second choice after cotton was noted last year, but no explanation was found, though

the plant was searched for nectaries. It was noticed by Mr. Kinsler that the keleps seemed to be giving especial attention to the midrib near its junction with the veins of the lower divisions of the leaf. Our lenses then revealed the fact that there are two minute raised wings or margins running along the upper side of the midrib and petiole, forming two narrow grooves in which the nectar is evidently secreted. The grooves are also protected by a row of fine hairs which project across them from the raised margin. The behavior of the kelep thus receives a practical explanation, and the tshubai finds a regular place next to the cotton among the plants protected by the kelep. The nectar-secreting habit of the tshubai may also explain its being eaten so readily by stock, and may help to give it standing as a forage plant, in spite of its weedy and unpopular relatives.

A second member of the composite family often visited by the keleps is the "sajal," a species of Melanthera (probably *M. deltoidea*), which also has local value as a forage plant, being eaten greedily by horses and mules, even in preference to grass. No nectaries have been found on this. A third composite, not yet identified, produces nectar in small depressions at the base of the leaf on the under side.

THE INVOLUCRE AS A PROTECTIVE STRUCTURE.

Cotton is the only plant known to be attacked by the boll weevil, and it is also unique among its relatives in the possession of a large leafy involucre. This may be a mere coincidence, or it may be that the weevil has had a considerable influence in the development of the involucre, depending upon the antiquity of the contact between the insect and its host plant. The involucre has, it is true, functions other than the exclusion of the weevils, since it takes the place of the calyx in protecting the young bud, but the reduction of the calyx probably followed the enlargement of the bracts, instead of preceding it. But however originated, the large bracts have, at the present time, a definite value in the problem of weevil resistance. There are several specialized characters which appear as though definitely calculated to increase the efficiency of the involucre in excluding the weevils from the young buds.

INVOLUCRAL BRACTS GROWN TOGETHER.

Both the Kekchi and Rabinal cottons frequently have the involucre closed at the base, the three bracts being grown together, thus making it impossible for the weevils to enter from below. In the Sea Island and Egyptian varieties, as well as in some of the Upland sorts, the bracts are not merely divided to the base, but they often have the lower corners rolled back, thus leaving an open passage for the weevils. The Rabinal cotton much excels all the other varieties thus

far studied in the extent to which the bracts are grown together at the base. Sometimes they are united for a quarter or even a third of their length. (Pl. IV, fig. 1, and Pl. X, fig. 1.)

APPRESSED MARGINS OF BRACTS.

In both of these Guatemalan varieties the margins of the bracts of young involucres are firmly and closely appressed, in striking contrast with the Sea Island and Egyptian varieties, where the bud is commonly exposed even when very young. This form of protection is effective while it lasts, but in the Rabinal cotton the involucre is too small, and the growth of the young bud soon separates the bracts and permits the entrance of the weevil. The United States Upland varieties are intermediate between the Sea Island and the Kekchi cottons in the degree to which the involucres are closed and the margins fitted together. A large proportion of the Upland involucres give ready access to the weevils, while most of those of the Kekchi cotton remain effectively closed for a longer period, as will be understood after a survey of the other involucral characters which conduce to the same result.

In one respect the firmly closed involucres of the Rabinal cotton seemed almost like an advantage to the weevil rather than the contrary, for the insect is not admitted to the bud until it is about large enough to furnish a place of development for a larva. The plant having taken control, as it were, of this relation, the weevils have not needed to possess an instinct against the destruction of young buds. Those of the open involucred Sea Island varieties often were attacked while still altogether too small to bring a larva to maturity. The advantage of the closed involucres lies, no doubt, in the fact that they shorten the period of access and allow some of the buds to escape which would be punctured either for feeding or for egg laying if the weevil has a longer opportunity. (Pl. IV.)

The Rabinal cotton culture is that in which the plants are cut back yearly to the ground. During the next month, or until the buds begin to develop on the new shoots, the weevils have no breeding places and nothing to feed upon except the leaves and leaf buds. In patches where the weevils are abundant the leaf buds are eaten out so persistently as to seriously interfere with the growth of the plants, and the very young flower buds were also reached in some instances by boring through the involucres. When attacked at this stage the buds wither and drop off. They serve the weevils only for feeding purposes, and their use in this way only postpones the time when breeding can be resumed.

The cotton at Rabinal was often overrun by two species of small black ants, identified by Dr. W. H. Ashmead as belonging to the

genera Solenopsis and Tapinoma.[a] There was no indication, however, that these afforded any protection against the weevils, although they might, perhaps, act as watchmen and scare weevils away when they happened to be present on buds or bolls where weevils had alighted, like other small ants which have been reported as attacking the boll weevil. The keleps belong in an entirely distinct category in being able to sting and carry off the weevils and make regular use of them as food. Instead of being of service to the cotton these small ants at Rabinal were a distinct injury; the Solenopsis was taking care of plant lice,[b] which often infested the cotton to a decidedly harmful extent. It continues and supplements the work of the boll weevils in stunting and distorting the plants. When the aphids are very numerous, the leaves are badly curled and growth is greatly impeded.

LARGE INVOLUCRES OF KEKCHI COTTON.

The Kekchi cotton has the bracts of the involucre much larger in proportion to the contained bud than the Rabinal cotton or than any of our Upland varieties. The possession of larger bracts constitutes a distinct weevil-resisting adaptation, since it permits the involucre to be more effectively closed and the protection to be continued for a longer time. Sooner or later, of course, the bracts must be separated by the growing bud. The larger the bracts the longer the bud can continue to grow before spreading the bracts apart. (Pl. IX, fig. 1.)

Prof. H. Pittier, who had charge of the Secanquim experiment in the latter part of the season, was especially impressed with the protective utility of the larger bracts of the Kekchi cotton, as shown by the following summary of his observations:

The large size of the bracts in proportion to the floral bud is a very important protective feature. In the Kekchi cotton the amplitude of these bracts is such as to completely inclose the bud at all times before the anthesis, and even in cases when they happen to be slightly separated the occlusion is maintained by the long hairs which fringe them on all sides. The length of these hairs constitutes a serious obstacle to the progress of the weevils, whose tarsi can not obtain a firm hold on the solid surface. I have seen them drop to the ground after many awkward attempts to gain access to the squares, while on the other hand the keleps did not seem to be impeded at all by the bristles.

[a] The material was not sufficient for a conclusive determination of the species. Doctor Ashmead says: "You have two distinct species of ants here. One, No. 1, belongs to the family Myrmicidæ and is apparently the worker of *Solenopsis picea* Emery; the other, No. 2, belongs to the family Dolichoderidæ and is apparently the worker of *Tapinoma ramulorum* Emery. I am sorry you did not have the different sexes, so that I could make positive of the species. In Solenopsis, as you probably know, there are four or five different forms, and it is not easy to identify from a single form."

[b] These have been identified by Mr. Theodore Pergande as *Aphis gossypii*, a species well known in the United States.

To show the increased size of the bracts in the Kekchi cotton, I have carefully measured over 250 squares of five of the most promising varieties of the Upland species. The dimensions taken were the length of the floral bud, and the length and breadth of the bracts. The table, in which these data are condensed in a comprehensive form, shows a decided advantage in favor of the Kekchi cotton.

TABLE I.—*Dimensions of floral buds and bracts of several varieties of cotton compared.*

Length of floral bud (millimeters).	Kekchi.			Parker.			King.			Allen.			Jewett.		
	Number of buds.	Length of bract.	Breadth of bract.	Number of buds.	Length of bract.	Breadth of bract.	Number of buds.	Length of bract.	Breadth of bract.	Number of buds.	Length of bract.	Breadth of bract.	Number of buds.	Length of bract.	Breadth of bract.
		mm.	*mm.*		*mm.*	*mm.*		*mm.*	*mm.*		*mm.*	*mm.*		*mm.*	*mm.*
5- 6	1	20	11												
7- 8	1	28	18	2	25	19				1	26	20			
9-10	6	39	27	13	31	20	5	33	19	18	34	21	3	38	26
11-12	5	42	30	16	36	24	7	34	23	10	34	22	2	36	21
13-14	3	42	30	18	39	25	9	40	24	18	37	23	10	39	26
15-16	4	42	30	8	38	23	6	44	25	13	39	24	7	41	28
17-18	8	47	33	6	39	26	6	40	24	5	39	25	5	39	30
19-20	2	52	30	3	43	24	4	42	26	1	49	29	1	52	38
21-22	1	37	27	3	48	26	1	43	25	1	40	26	2	47	34
23-24	3	47	36	1	36	25	2	41	26	5	40	23			
25-26	2	42	30	3	37	25				1	32	21	1	48	33
27-28				2	44	25	2	40	25	5	42	25			
29-30				2	45	24	1	49	28						
31-32				1	47	30									
33-34													1	42	32
Total	31			78			43			78			32		

The advantage is particularly notable with respect to the greater width of the bracts, which enables them to remain much more effectively closed at the angles. In the Parker, King, and Allen varieties the bracts very seldom attain a width of 30 mm., while in the Kekchi cotton the average width for all except the smallest buds is above 30 mm.

OPENING, OR FLARING, OF BRACTS AVOIDED.

The unusually large and well-closed bracts of the Kekchi cotton have another practical use in keeping the bud from drying out, as explained in the discussion of proliferation.

The external indication of this difference is that in the Kekchi cotton punctured squares commonly do not open, or flare, by the spreading apart of the involucral bracts, while among the Upland and Sea Island varieties flaring is the regular rule. Quite a percentage of the squares of Abbasi, Parker, King, and other varieties stand well open normally before any injury has occurred, but the Kekchi cotton seldom or never exposes its squares before flowering. The larger and broader involucre is also able to permit the protrusion of the flower without losing the power of closing and remaining shut for a considerable period after flowering, while the Parker and King varieties often remain quite open, so that the young boll is fully exposed to the weevils.

An example of the promptness with which weevil injuries cause the involucres of our Upland cotton to open is well shown in a note by Mr. McLachlan:

On August 8, at 2 p. m., a small cage was placed over a small plant of Parker cotton, and 5 female and 2 male weevils were introduced. The plant possessed 36 squares, 4 flowers, and 9 bolls. The morning after the weevils were put into the cage several of the squares had flared and one had fallen. It would seem that the mechanical forces of the square are quickly affected by the work of the weevils. Here, of course, the punctures were numerous, because of the many weevils on the plant. Some of the squares were riddled with feeding and egg punctures.

The buds of Kekchi cotton often recover from three or four punctures, though they might not do so if these were all made at the same time. But it often happens that squares with numerous feeding punctures remain closed and wither up without flaring.

HAIRY MARGINS OF INVOLUCRAL BRACTS.

In addition to their larger size, the bracts of the Kekchi cotton have the marginal teeth or laciniæ more numerous and more hairy than those of our Upland varieties and able to afford more of an impediment to the entrance of the weevils. The difference was very pronounced in our experimental plot, where King, Parker, and other familiar American sorts were planted beside the Kekchi. It is as superior in this respect to the other Upland varieties as they are to the Sea Island.

The Kekchi and Rabinal varieties, though both belonging to the Upland series and having many similarities, have also very distinct differences, as, for example, in the present character. The small, firmly appressed bracts of the Rabinal cotton have the marginal laciniæ few and small; sometimes the edges are nearly entire, or merely toothed. The hairy covering is also reduced to a fine, short coat, which can afford little or no impediment to the weevils.

EXTENT OF PROTECTION BY INVOLUCRE.

That the closed involucres do indeed contribute to the protection of the young buds from the weevils became very obvious in one of our experimental plots at Secanquim, located about a quarter of a mile outside the belt of Indian cultivation of cotton. There being no keleps to afford protection, the cotton soon became thickly infested with weevils, and very few bolls were allowed to develop on any of the plants. There was a notable difference, however, in the age at which the buds were punctured. As already stated, the edges of the bracts of some of the Sea Island and Egyptian varieties separate at a much earlier period than those of the Upland varieties, and the

weevils commonly attack them in their very early stages, and even while they are altogether too small to permit the development of a weevil larva. It has been pointed out already by Messrs. Hunter and Hinds that the smooth stems and petioles of the Sea Island and Egyptian cottons render them much more readily susceptible to injury by the boll weevil than are the Upland types, and if we add to this the disadvantage arising from the later development and the more open involucres the possibility of protecting the long-staple cottons against the weevils seems small indeed.

Instead of being immune to the boll weevil, as at one time hoped, the Egyptian and Sea Island varieties seem to be most lacking in weevil-resisting adaptations, as might, indeed, have been expected in view of the fact that they have been developed in regions to which the weevil has not yet penetrated. The Kidney cottons, which may be looked upon as representing the Sea Island type on the mainland of the American continents, have, as will be seen later, a peculiar feature of protective value.

ADVANTAGE OF OPEN INVOLUCRES.

It will be apparent from the facts already recited that the partly closed involucres of the Sea Island and Upland varieties now cultivated in the United States serve little or no purpose in resisting the boll weevil. On the contrary, they often appear to be an advantage to the insect, serving, as they do, to hide the parasite from its enemies and protect it against the application of insecticides or capture by insectivorous birds.[a]

The great variation in the size and shape of the involucre in the different varieties of cotton suggests the practicability of securing sorts with open involucres or with these structures reduced to small dimensions. If the weevils were to be caught by insectivorous birds, like the Cuban oriole, whose weevil-eating habits have been discovered by Mr. E. A. Schwarz, open involucres would be a distinct advantage. It might then be possible also to apply Paris green or other insecticides to young buds which are, except in the early spring, the exclusive feeding places of the weevils.

The practicability of an open involucre will need, however, to be considered from another standpoint. It must be ascertained whether the young buds will bear full exposure. Unlike most of the related plants, the cotton bud is not protected by a calyx. The involucre may be necessary as a substitute, especially in dry climates. In humid

[a] Dr. H. J. Webber states that the desirability of open involucres has been appreciated and that selections of Upland varieties with a view to the development of this character have been made.

regions, however, this requirement might be relaxed, and it is in such places that the injuries of the weevils are the greatest.[a]

BEHAVIOR OF PARASITIZED BUDS.

SHEDDING OF WEEVIL-INFESTED SQUARES.

In a dry climate, like that of the Mexican plateau region, the dropping of the squares in which the weevils have deposited eggs would constitute a very effective adaptation. The weevil larvæ do not survive a thorough drying out of the squares. It is only in the arid districts of Mexico that the cotton plant has shown its ability to escape from cultivation and maintain itself without human assistance, if indeed it be not in some places a truly indigenous wild plant, as several botanists have reported. But in a moist region like the cotton belt of eastern Texas this habit of the plant has no practical use, since as many of the weevils die when the injured squares remain attached to the plant as when they fall to the ground.

"It is generally true that squares seriously injured by the weevil sooner or later fall to the ground. Some plants, however, shed the injured squares more readily than do others. It seems to be a matter of individual variation rather than a varietal character. Thus occasional plants retain a large proportion of their infested squares, which hang by the very tip of the base of the stem. Normally the squares are shed because of the formation of an absciss layer of corky tissue across their junction with the stem. In the case of the squares which remain hanging, the formation of this layer seems to be incomplete, or else it becomes formed in an unusual plane, so that while the square is effectually cut off, it merely falls over and hangs by a bit of bark at its tip. In this position it dries thoroughly and becomes of a dark brown color. Plants showing 6 or 8 of these dried brown squares are quite common in infested fields. Although exposed to complete drying and the direct rays of the sun, the larvæ within are not all destroyed. * * *

"It seems a conservative estimate, therefore, to say that fully one-third of these exposed dried squares may be expected to produce adults. Considering the exposed condition of such squares this seems to be a very high percentage. * * * The observations made, however, certainly show that a complete

[a] After the above had been written it was observed that the Pachon cotton from western Guatemala, grown in an experimental plot at Lanham, Md., has the peculiar feature of a large calyx, which completely covers the young bud and extends above it into long, slender, hairy tips. It may be that this is to be looked upon as still another weevil-resisting adaptation. The weevils would be able, undoubtedly, to bore through the calyx, but the hairy tips might hinder their access to the bud. The bracts are much smaller and much more open than in the Kekchi and Rabinal varieties, but the laciniæ, or teeth, along their margins are rather stiff and are clothed with numerous hairs, stronger and more bristlelike than in the Kekchi and Rabinal varieties, and able to keep the laciniæ from closing together. It may be that the greater rigidity of the laciniæ and the bristles gives better protection than the open position of the bracts would indicate. The case is in reality quite different from that of the Sea Island varieties, where the bracts are both naked and open.

drying of the square does not necessarily destroy the larva, and that a square may undergo far more exposure to direct sunshine than had been supposed possible without causing the death of the larva or pupa within."[a]

It is to be remembered, however, that such disconnected squares are thoroughly dampened every night by the dew, and that a small amount of moisture may pass out from the plant through the shred of dead tissue. In either case the hanging boll might get more moisture and less heat than if lying on the dry ground, exposed to full sunlight. Suspended bolls are exposed to air temperatures only.

If no other means of avoiding the weevil becomes practicable a great extension of the cotton production into the semiarid districts of western Texas, Oklahoma, and even Kansas is to be expected. The long days of the more northern districts will conduce to the shortening of the growing season, and if dry weather cuts down the yield the loss is likely to be neutralized by more or less complete protection against the weevils.

These contradictory effects of the same adaptation depending upon climatic condition may render necessary a complete differentiation of the cotton varieties of wet and dry regions.

It is not improbable that the Upland varieties previously known in the United States came originally from the more or less arid regions of Mexico, where absence or very small development of the basal branches keeps the ground from being constantly shaded and gives better chances for the weevils to be killed by the drying out of the fallen squares.

Our Upland cottons are undoubtedly of American origin, but the region from which they came has not been ascertained. Some of the Texas varieties are said to have been brought from Mexico. Coronado's Journal of the earliest Spanish exploration in Arizona and New Mexico contains many references to the cultivation of cotton by the Indians. There can be little doubt that the agricultural Indians of the Gulf region also cultivated cotton, though no documentary evidence of the fact seems to have come to light as yet.

It is highly probable that the original home of the cotton plant, and of the boll weevil as well, was in a somewhat arid region, since it is only under such conditions that the weevil would be effectually prevented from increasing to the fatal degree of destroying its host plant, and thus cutting off its only means of subsistence. On the other hand, it was only in a humid country like eastern Guatemala that many of these weevil-resisting adaptations would be likely to develop if, as now appears, it has required the selective influence of the boll weevil itself to bring them to their present advanced development.

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[a] Hunter, W. D., and Hinds, W. E., 1904. The Mexican Cotton Boll Weevil. Bul. 45, Division of Entomology, U. S. Department of Agriculture, pp. 73 and 74.

The adaptive character of this habit of shedding the parasitized squares seems to be confirmed by the fact that it depends upon the existence of a special layer of soft cells which readily break down when the bud is injured. Many plants have such cells as a means of shedding their fruits, but they seem not to be prevalent among the relatives of the cotton. The cotton itself does not drop the ripe bolls, and even the empty shell often remains long after the seeds are gone.

The drier the climate the more effective is the prompt shedding of injured squares. Whether there are other adaptations thus especially suited to dry climates is not yet known, our studies having been confined mostly to humid regions.

Dr. Edward Palmer, who has spent many years in botanical explorations of the dry plateau region of Mexico and who discovered that the boll weevil was a cotton pest, states that in several localities where the cotton was formerly grown without difficulty the introduction of irrigation improvements has proved disastrous. With the assistance of the moist soil the weevils are now able to reach maturity in large numbers and complete the devastation of the crop, quite as in Texas. The irrigated soil affords a situation favorable for the development of the larvæ in the fallen squares.

This is said to have been the case about Parras, and at Rio Verde, below San Luis Potosi. The culture of cotton has declined also in the "Huasteca Potosina," the tropical district between San Luis and Tampico, and on the Pacific side of Mexico, along the Santiago River above San Blas, as well as about Tepic. Doctor Palmer saw cotton growing in a wild condition in the fences at the old mission, San José de Guaymas, 6 miles from the commercial port; again at Mulegé, Lower California, across the Gulf from Guaymas, the latter a much-branched, prolific tree, producing a nankeen-colored lint. About Guaymas cotton was formerly utilized by the Indians as tinder, after being dipped in a solution of saltpeter. The same facts were observed by Dr. L. O. Howard in 1899 at San José de Guaymas.

COUNTINGS OF FLARED AND FALLEN SQUARES.

An attempt was made in connection with our Guatemalan experiment to secure data on which a definite statement might be based regarding the extent to which the different varieties were protected by their involucral characters, but the problems are too complex to be reached except by more elaborate statistical studies than were practicable at that time.

Countings were made, for example, of the flared and fallen squares—that is, of those which it might be supposed that the weevils have injured—and of the number of weevil larvæ, proliferations, etc., found inside them. The results in percentages do not agree, however,

with the facts obvious in the fields; indeed, they greatly misrepresent them. Thus the percentage of weevil injuries in flared and fallen squares does not appear very much higher in the Kekchi cotton than in the Sea Island and Upland varieties; yet as a matter of fact the squares of the Kekchi cotton seldom flared for any other reason than weevil injuries, and much less often for this cause than did those of other varieties. Many small squares of the Kekchi cotton fall off, however, before they are large enough or open enough to be attacked by the weevils.[a] This takes place in the other varieties to a much smaller extent, but with them the apparent percentage of weevil injuries among flared squares is much diminished, because many squares stand open and appear as though beginning to flare, even before the weevils have attacked them.

PROLIFERATION OF INTERNAL TISSUES OF BUDS.

The protection of the buds does not end with devices for the exclusion of the adult weevils, nor with the rejection of those in which they have laid their eggs. It is also possible for the plant to heal the wound, and bring the injured bud to maturity by preventing the growth of the weevil larva. Where the climate is dry the weevil larvæ in the rejected buds are killed, as already explained. The humid climate alternative of the falling of the parasitized squares is proliferation, the growth inside the bud of loose, watery tissue in which the larva does not develop. Whether the larva is killed by smothering, starving, or poisoning, or by some combination of these, is not yet known. Starvation is a sufficient explanation, since the material with which the larva becomes surrounded can be no adequate substitute for the highly nutritious pollen grains on which the infant larva would otherwise feed.

Proliferation is much more frequent in the Kekchi cotton than in any of our United States varieties, as far as known. The first and second punctures are commonly resisted successfully, but the third, fourth, or fifth attempt may succeed in the development of a larva. The proportion of weevil punctures rendered ineffective by proliferation was found to run well above 50 per cent, sometimes between 80 and 90. (Pl. V.)

The promptness and efficiency of proliferation bear an inverse proportion to the size of the buds. As the latter grow larger the mass of anthers inside becomes less compact, and the other tissues become too

[a] Professor Pittier found in the latter part of the season that the buds of the Kekchi cotton were sometimes cut away at the base and left hanging in a wilted condition. These were at first taken for flared squares as the result of weevil injuries, but it was later ascertained that this was not the case, though the true cause was not learned. The damage was done in the night.

nearly mature to put forth new growth. If the presence of the larva at this stage is sufficient to cause the bud to fall off, the development of the parasite to maturity is well assured, the large bud affording good protection and adequate food.

In the Kekchi cotton, however, such late attacks very seldom cause the bud to fall off. Larvæ developed in the larger buds are turned out of doors, as it were, by the opening of the flower. The tendency of injured buds to persist is notably greater than in the United States, either because of some physiological difference between the varieties, or because of the larger and more firmly closed involucres of the Kekchi cotton, which keep the buds surrounded with a moist atmosphere and protect it against drying out while the new tissues are forming to heal the wound and encyst the egg.

In the closely planted Indian fields the squares seldom flare as in the Texas varieties. They generally remain in place and continue to grow until the bracts have reached nearly their full normal size. In fields partially protected by the keleps the weevil larvæ do not seem to develop in buds as small as in Texas. Proliferation may partly explain this delay and also the more firmly closed involucres, but in our unprotected plot the weevils were able by repeated punctures to infest smaller squares and reach maturity in them, after they had fallen to the ground.

The behavior of weevil larvæ inside the squares in Guatemala seems also to differ appreciably from that observed in Texas where younger squares are usually much more accessible to the weevils, and are commonly punctured. In Texas the larvæ regularly grow to maturity, depending for food upon the pollen, which is completely eaten out. In Guatemala this very seldom occurs. Small squares with well-developed weevil larvæ are rarely found under normal conditions, nor do the larvæ depend upon the pollen as their principal article of diet, as in Texas.

Several reasons for this difference may be considered. The first is that the larger and more firmly closed involucre of the Kekchi cotton gives the buds several days of protection, so that the average size would naturally be larger. The examination of large numbers of squares picked at random from the Indian cotton fields by Messrs. Kinsler and McLachlan show also that a very large proportion of the punctures are followed by proliferation, and that this means of protection is much more efficient in the younger squares. Another reason must be sought, however, for the failure of the larvæ to eat the pollen of the large buds where proliferation is less prompt and less frequent. The impression might be gained that the pollen of the Kekchi cotton is in some way not acceptable to the weevils, since even when there is an abundance of pollen at hand they prefer to eat out

the style and central column of the flower, and thence down into the ovary or young boll. After this has been consumed the larvæ return to the upper part of the bud to finish the remainder of the pollen.

Nevertheless, this suggestion of a protecting quality in the pollen itself can not be accepted with much confidence because the weevils showed in numerous instances that they could live and thrive upon the pollen of the young squares, quite as in the United States. This occurred in the experimental plot where there were no keleps, and the weevils were very numerous and persistent in their attacks. After two or three punctures the squares flared and fell to the ground in the usual manner, and in these the weevil larvæ were able to reach maturity.

A more probable reason for the usual failure of the larvæ to eat the pollen as freely as in the United States is furnished by the opinion of Mr. W. D. Hunter, that the original habit of the weevil was to attack the bolls, like related species of Anthonomus, which live upon various kinds of fruits.[a] If this be true with reference to the boll weevil we may think of the Guatemalan members of the species as having retained somewhat more of the ancestral habits which with them are definitely useful, because the cotton variety with which they have to deal has perfected, to a larger extent than the Texas varieties, the art of proliferation.

As a further indication of the greater strength among the Guatemalan weevils of the instinct of attacking the ovary of the bud may be mentioned the fact that a very large proportion of the punctures occur low down—that is, on or below the level of the apex of the young boll. The larva commonly eats directly to the center of the bud and hollows out the apex of the young boll. This habit gives rather less opportunity for successful proliferation than in Texas, because the cavity hollowed out by the larva lies below the level of the staminal tube, the tissues of which are the most active in proliferation. The Kekchi cotton shows occasionally another form of proliferation not recorded from Texas, namely, that of the base of the corolla. Sometimes this enlargement takes place in an outward direction, forming a wart or protuberance on one side of the bud, as shown in Plate VI. In other instances the direction is reversed and the ingrowing edges of the wound made by the weevil fill the internal cavity and prevent the development of the larva. The proliferation of the corolla, besides being less

[a] A new species of Anthonomus with habits closely identical with those of the boll weevil, but parasitic on the pepper plant (Capsicum), has been discovered recently in Texas by Mr. E. A. Schwarz. This gains an added interest from the fact already noted that it is the regular custom of the Indians of Alta Vera Paz to plant peppers among the cotton.

frequent than that of the staminal tube, is probably also less effective, since the weevil larvæ could escape before it into the center of the flower while the proliferation from the staminal tube grows outward, as though to meet the intruder and keep him separated from the more special organs.

The habit of the larvæ to seek the center of the bud and gnaw off the style is responsible for the loss of large numbers of younger bolls which have suffered no direct injury from the weevil. Even though the larva be subsequently killed by proliferation or though the flower drops off and carries the larva with it, the lack of pollination must prevent the development of the young boll unless parthenogenesis takes place, which seems improbable.

Larvæ were found in several instances in nearly full-sized buds about to open, and in another case a more than half-grown larva was found inside the central column of an open flower. More or less distorted flowers with unmistakable signs of previous proliferation in the bud stages are commonly found in the Kekchi cotton fields.

Summarizing the results of the study of proliferation in the Kekchi cotton, it may be said that although the frequency of proliferation in the young squares is very great, its efficiency in preventing the breeding of the weevils is somewhat less than might be expected in Texas, owing to the difference of food habits among the weevils. If the Texas weevils are as consistent in their habits as now supposed, the introduction of the Kekchi cotton or of a similar proliferating variety might be of great benefit as a preventive measure. The extent, however, to which it could be made to compass the complete destruction of the weevil would depend somewhat upon the degree, if any, to which they might return to the habit shown in Guatemala of feeding upon the ovaries or boll rudiments rather than upon the pollen of the young buds, an important and hitherto unsuspected difference in habits between the weevils of Texas and those of Guatemala.

CAUSES AND CONDITIONS OF BUD PROLIFERATION.

That the proliferation is occasioned by the injuries of the weevil is too obvious to admit of doubt, but it may be of much practical importance to learn the exact way in which the new growth of tissue is brought about. The disturbing factor might be either mechanical or chemical. The new growth may be a direct response to injury of the weevils in feeding or laying eggs, or it might be stimulated indirectly by the secretions of the young larva, or by chemical changes or decay of the damaged tissue. A second mechanical possibility is that of pressure developed in the young and rapidly growing bud.

The burrowing of the weevil relieves this pressure at one point, and may thus furnish the exciting cause of the rapid growth in this direction of the tissue of the staminal tube.

It seems not improbable that a relation will be found between the method of culture and the extent and frequency of proliferation. Open-field conditions, with much bare ground about the plants, would increase the daily exposure of heat and dry air, and this would conduce to the wilting of the punctured squares, which might then be expected to flare and fall off instead of remaining to proliferate. The result of weevil work in our open-culture plots was obviously different from that in the more crowded cotton fields of the Indians. On the widely separated plants the squares often fell off and permitted the larvæ to develop, as in Texas, except that there was still a distinct tendency on the part of the larvæ to attack the pistil and ovary first, before eating out the pollen.

PROLIFERATION IN OTHER VARIETIES.

Proliferation is by no means confined to the Kekchi cotton, but probably occurs, occasionally at least, in all the Upland and Sea Island varieties. A noteworthy Guatemalan Sea Island cotton was found by Mr. Kinsler in the aldea of San Lucas, a few miles from Secanquim.[a] Both the buds and the bolls afforded fine examples of effective proliferation. Even the Egyptian varieties showed a distinct ability in this direction. In one instance no less than 17 of 23 punctured squares of Jannovitch had proliferated, and 15 cases seemed to have been effective.

Proliferation ceases to occur when the bud has become too large. The anthers are no longer so closely packed together and the tissues of the staminal tube are too nearly mature. By that time, however, the style may be sufficiently developed to furnish adequate food. It is well known, however, that the period of development of the weevil larvæ may be greatly prolonged, and this would seem likely in the present instance, since the tissues of the styles must be less nutritious than the pollen. The delay also would be advantageous, since it would permit the young boll to become larger.

[a] This variety is peculiar in having about half of each seed covered only with a very fine, short, bright bluish-green lint. The upper half bears the long white fiber, and is smooth and black when this has been removed. Some of the plants had excellent crops of bolls, unusually uniform in size and apparent age, as though the habit of seasonal flowering were well accentuated. The variety is evidently perennial and grows to a height of from 6 to 8 feet, but on the other plants the leaves, flowers, and bolls were much reduced in size. The plants were all occupied by small black ants. On some of them no weevils nor any indications of weevil injury were found, but others only a few rods away were badly infested.

But as the power of effective proliferation declines in the larger buds another factor of protection comes into play. The later the attack of the weevil the greater is the chance that the bud will mature and the flower will open and turn the weevil larva out of its quarters to die. And since buds commonly mature which have been attacked while still young enough to proliferate, it is easy to understand why attacks made in the later stages seem to be effective only in exceptional instances.

An element of uncertainty often attaches to the enumeration of weevil injuries because of the difficulty of finding the egg or very young larvæ of the weevil in the squares which have been only recently attacked. This is especially true in small squares where the anthers are still white and of about the same color, size, and general appearance as the eggs. The possible error does not, however, materially affect the result, since it is to be expected that the same proportion of bolls will proliferate and the same percentage of weevil larvæ develop as in the squares which are far enough advanced to show definite results.

PROTECTION OF THE BOLLS.

If it be true, as already intimated, that the original habit of the weevil was to attack the boll instead of the bud, the opportunity for the selective development of protective characters of the boll has been greater. This suggestion seems to accord with the results, since the boll of the Kekchi cotton has a series of protective characters even more striking and effective than those of the involucre and the bud.

PERSISTENCE OF FLOWERS.

As long as the flower remains in place the young boll is thoroughly protected, the weevils having no means of access except by boring through the withering tissues, which seems not to be attempted. In the Kekchi cotton the flower falls only when detached by the swelling of the young boll. This may also be true of other varieties. (See Pl. IX.)

The frequent sequel of proliferation in the bud, as noted above, is the loss of the young boll through lack of pollination. This is especially true in Guatemala, owing to the tendency of the weevil larvæ to eat away the style. On one occasion Mr. Kinsler collected from a field of Indian cotton 28 young bolls showing signs of debility. These measured from 13 to 20 mm. in length, most of them about 15 mm. None of the smaller bolls showed signs of weevil injury, but in many of them the ovules were already shriveling up. A few punctures were found in some of the larger bolls, and in some of these proliferation had occurred. The development of the weevil larvæ to maturity

seemed unlikely in any case, because the unfertilized ovules were already withering.

Presumably there are various stages and degrees of fertilization. Some of the stigmas of proliferated buds seem to have adequate pollen, so that the bolls can develop normally, while others obtain none at all or only a little. The persistence of injured flowers is much greater. They may not fall off at all, and often remain attached by the withered style to the boll when nearly full size.

It thus happens that injured flowers protect their young bolls longer than the others, but in most instances such bolls remain small or unsymmetrical, presumably as a result of inadequate fertilization. It is quite possible, however, for normal bolls to develop occasionally from weevil-infested buds which never open, for the style often pushes through and becomes fully exposed, so that fertilization by pollen from another flower might readily take place.

IMMUNITY OF VERY YOUNG BOLLS.

For reasons not yet ascertained, the weevils in Guatemala seldom or never attacked the very young bolls. This may be due to a conservative instinct on the part of the weevil, like that which forbids the laying of any additional eggs in a bud already parasitized.[a] It is not impossible, however, that the oil glands with which the surface of the young boll is very thickly beset may have a protective function. As the boll grows larger the glands do not appear to increase in numbers, but become separated much more widely. On bolls of the Kekchi cotton the oil glands are usually absent from a distinct longitudinal band running down the middle of each carpel. (Pl. VII.) A large proportion of the weevil egg punctures are made along this naked band, although very few of them take effect. The wall is thicker here, and the weevil in boring meets the tough lining of the boll chamber at an angle, and is seldom able to penetrate. If this interpretation of the facts be correct, the naked band constitutes a veritable weevil trap, a device for inducing the weevil to make its punctures and lay its eggs in the part of the boll where they can do no harm.[b]

To ascribe a protective value to the oil glands is not unreasonable in view of the fact reported by Messrs. Quaintance and Brues,

[a] Hunter, W. D., and Hinds, W. E., 1905. The Mexican Cotton Boll Weevil. Bul. 51, Bureau of Entomology, U. S. Department of Agriculture. p. 78.

[b] This peculiarity of a glandless longitudinal band in the middle of each carpel was also noticed in a variety of cotton cultivated by the Moqui Indians of Arizona, grown in 1904, in the Department's plant-breeding experimental field at Terrell, Tex. The Moqui cotton is interesting also by reason of its short, squarish, distinctly apiculate bolls, more like some of the Old World cottons than are those of other members of the Upland series.

that the Egyptian cotton, the bolls of which are excessively oily, is on this account immune from the bollworm.[a] The oil contained in the glands has a deep-brown color, a sticky, molasses-like consistence, a disagreeable, pungent odor, and a sharp, resinous taste, suggesting turpentine or Canada balsam.

The development of the oil glands seems to be especially great in the Egyptian variety known as Mit Afifi, and the glands are more superficial. By slight pressure, or by drawing the nail across the surface, the oily liquid is freely obtained. Most of the Upland varieties have the oil glands much more scattering and deep set than the Egyptian sorts, and it is not possible to squeeze the resin out of them in any such manner.

On Redshank and other Upland types the resin glands are marked by slight superficial depressions, but a cross section shows them to be well below the surface, with several layers of chlorophyll-bearing cells between. On the Egyptian sorts the glands are also set in depressions, but the gland itself is very close to the surface, and makes the bottom of the depression again convex, the superficial layer of cells being very thin. It seems to break spontaneously in some instances; at least there are frequently small spots of hardened resin, and very slight pressure brings out the dark, gummy fluid. The fingers receive a permanent brownish stain, which with the acrid, biting sensation experienced when the liquid is applied to the tongue, increases the probability that substances of a definitely protective character are present. It is well known that many of the aromatic oils are for some reason highly distasteful or even fatal to many insects.

The Sea Island and Kidney cottons have the oil glands conspicuously developed, like the Egyptian varieties, but the Old World cotton (*Gossypium herbaceum*) is in this, as well as in other respects, more nearly related to the American Upland cotton (*Gossypium hirsutum*). The Aidin (Asia Minor) variety of *Gossypium herbaceum* has the oil glands rather small and deep set, with the superficial pits rather shallow, more so than the Ceylon or Korean types.

Even the petals of the Guatemalan Kidney cotton found at Trece Aguas[b] contained oil glands. The color of the petals was a uniform pale yellow, without purple spots on the inside, but in the upper

[a] Quaintance, A. L., and Brues, C. T., 1905. The Cotton Bollworm, Bul. 50, Bureau of Entomology, U. S. Department of Agriculture, p. 71.

[b] The Kidney cotton at Trece Aguas is called *paiyi*, and seems to have little or no relation in the minds of the Indians with the dwarf Upland cotton, which is called *nok*. In the Secanquim district, only a few miles away, this name *paiyi* (pronounced like the English words *pie ye*) is not recognized. Kidney cotton, though apparently not now planted by the Indians, is not entirely unknown to them. They call it simply *che nok*, or tree cotton.

half specked with minute brown glandular dots.[a] The oil glands of the bolls of this Kidney cotton are apparently quite as strongly developed as in the Egyptian varieties, or even more so. They are distributed very irregularly over the surface, and are not lacking above the dissepiments, along the middle of the carpels. The position and structure of the glands seem also to be the same as in the Egyptian cottons. They are close to the surface and show as distinct black spots, there being no green tissues over them as in the Upland and *herbaceum* types.

I am indebted to Mr. Guy N. Collins for the suggestion that the present inefficiency of the oil glands as a means of protecting the cotton from the boll weevil furnishes no argument against the adaptation of the glands nor their development through the selective agencies of the boll weevil itself. This fact is sufficiently obvious when once stated, but it is not commonly taken into account in considering questions of this kind. We may be sure that the gradual development of a protective character like the oil gland would carry with it a corresponding increase in the power of the weevil to avoid or to endure the injury. The ultimate value of the device would depend on whether the glands were able to keep ahead of the weevils in quantity and distastefulness. The readiness with which the boll weevils attack the Egyptian cotton renders it obvious that oil is now no adequate protection, but the preference of the weevils for the unprotected strips of the bolls of the Kekchi cotton indicates that the weevils still dislike the oil, though they may have foiled the attempt of the plant to protect itself in this way.

There are two attendant facts which under certain circumstances might readily obscure the immunity of the young bolls. Many such small bolls fall off, a particularly large number it seemed from our row of Parker cotton, but an examination of these failed to show anything in the way of weevil injuries, except such as had been inflicted while the bud or flower was still in place, the style and a small apical cavity having been eaten away in numerous instances. Many small bolls were to all appearances quite uninjured. They may have been rejected by the plant as supernumerary, the plant being unable to furnish the food material needed to bring them to maturity, or they may have failed of fertilization as a result of weevil injuries to the bud or from other causes, such as the absence of bees, which were extremely scarce in the Guatemalan cotton fields. The frequency with which the boll weevils were found inside the

[a] The flowers of the Kekchi cotton are pure creamy white when young and as long as they remain open. When old and rolled together they become a pinkish red. They are not yellow or bluish at any stage. The stamens and pistils are also nearly white, the latter with rows of oil glands showing as small grayish dots.

cotton flowers and well dusted over with pollen suggests the possibility that in this district at least they were a not unimportant agency of cross-fertilization. The performance of such a service by the boll weevil would be comparable to the famous case of the yucca and its moth, the plant being dependent for cross-fertilization upon its insect parasite. The weevils eat the pollen from the bud: that they visit the flowers for the same purpose seems highly probable. The investigations of Messrs. Hunter and Hinds have shown, indeed, that a pollen diet is a necessity for the complete sexual maturity and reproduction of the weevils; if without buds to feed upon they seldom copulated and never laid eggs.[a]

RAPID GROWTH OF YOUNG BOLLS.

Mr. John H. Kinsler, who gave careful attention to the earlier stages of the Guatemalan experiment, gained an impression that the young bolls of the Kekchi cotton increased in size with a rapidity distinctly greater than that of the United States Upland varieties planted alongside. It was not practicable to establish the fact by carrying out a series of daily measurements, though it was possible to ascertain from dated tags used in connection with the hybridization experiments that the Kekchi cotton can grow bolls to full size in less than a month from the time the flower opens. Plate IX, figure 2, shows on the right two bolls of Kekchi cotton less than a month from flowering. On the left are the two largest bolls from an adjoining plant of King, the seed of both varieties having been sown the same day.

Such an acceleration of the growth would be of very obvious utility in lessening the period in which the danger of infestation is greatest. A large proportion of the weevils found in adult bolls of Kekchi cotton were in "locks" or compartments of diminutive size, showing that the infestation had taken place while the boll was less than half grown. Indeed, the weevils seldom seem to be able to affect lodgment in bolls more than half grown, although numerous attempts are made in fields where the weevils are numerous. The following field note describes such an instance:

> A boll showing many external marks of weevil punctures was found on being cut up with care to have been attacked at least fourteen times. In five cases the outer wall seemed not to have been penetrated, but in nine others there had been complete perforations. All of these had been closed, however, by proliferation from the inner surface, and no living larvæ were found.

Such persistent attacks, however, may finally induce a diseased condition which interferes with the normal growth of the boll, even

[a] Hunter, W. D., and Hinds, W. E., 1905. The Mexican Cotton Boll Weevil, Bul. 51, Bureau of Entomology, U. S. Department of Agriculture, p. 113.

though the weevils be successfully resisted. Such injured bolls often show a brownish discoloration of the interior tissues near the base and connecting with the nectaries, which may indicate a bacterial disease, to be discussed later. Sometimes this affects the walls only, sometimes one or more seeds and the surrounding lint.

THICK-WALLED BOLLS.

In the Kekchi cotton there are considerable variations in the thickness of the outer wall of the boll. Not infrequently the wall equals or exceeds the length of a weevil's snout, so that only the largest or longest snouted weevils would be able to make an opening into the interior cavity. It was noted, also, that on the inside such bolls are often quite free from these injuries or small larvæ, though numerous attempts may have been made. Large larvæ or pupæ may be found, but these have come, obviously, from eggs laid while the boll was still young. On some plants the development of large thick walls takes place very promptly, so that a protective character of considerable value might be obtained if this feature could be increased and rendered constant. Early development of the thick walls was indicated by the fact that the young seeds and lint did not fill the cavity, and the seeds were still far from mature. Instances might be drawn from other plants where the growth of the pod or seed vessels far outruns the seeds at first, so that the development of such a character in cotton might reasonably be expected.

Even when a wall thicker than usual has been bored through, the egg must be laid on the outside of the mass of lint which still intervenes between it and the young seed, so that the larva's chances of development are greatly lessened. As will be shown later in the discussion of proliferation in the bolls, the instances are very numerous in which, although the wall is penetrated, no further damage results; either the egg is not laid or the development of the larva is prevented by proliferation. In any event the boll escapes further injury, and it is a very significant fact that in the dissection of a large number of such bolls of Kekchi cotton scarcely any young larvæ were found, in spite of the fact that most of them had been punctured not once only, but many times.

TOUGH LININGS OF CHAMBERS OF BOLLS.

The three, four, or five chambers which contain the locks of cotton in the unopened boll have each a complete membranous lining. In the Kekchi cotton, at least, this is extremely tough and parchment-like, even in bolls not yet full grown and in which the seeds are not yet fully formed. This membrane is readily separable from the more fleshy external layers of the boll, and though flexible, it is very

firm and incompressible, and resists tearing unless considerable strength be exerted.

A large percentage of attempted punctures of the larger bolls failed because the weevils are unable to penetrate this protective lining. This fact is readily determined by the study of radial sections of the outer wall through the warts which mark the weevils' points of attack. The different texture of the new tissue which has closed the wound shows, usually, that the cavity eaten out by the weevil extended down to the tough basal lining, even when no evidence of the injury has become apparent on the inside. In other instances, also very frequent, the new tissue, developed as a result of the irritation of the attempted puncture, exceeds the cavity and causes an inward swelling or prominence of the inner lining analogous to the projecting warts which are the usual external indication of weevil punctures.

It occasionally happens, too, that the projection of the new tissue occurs almost entirely in the inside, the external wart being very slightly developed or not at all, though the new tissue and the inner swelling show that a puncture had been attempted.

The utility of this lining as a means of excluding the boll weevil seems not to have been considered heretofore, and there has been no opportunity as yet to compare the Kekchi cotton with other varieties with regard to this feature.[a] Certain it is, however, that in the Kekchi cotton the parchment lining is almost as firm and tough as that which surrounds an adult coffee seed. And it is certain, also, that a very large proportion of the attempted punctures of the bolls failed to bore through this inner wall of defense.

The examination of a large number of bolls, which were full size or nearly so, though still far from maturity, in most cases failed to find more than a very few instances, if any, of very recent perforation, though there were large numbers of instances where the weevils had gnawed their way down through the parchment and deposited an egg. In many such cases the proliferation or new growth induced by the injury causes the parchment to be raised up from the wall on the inside to form a blister-like, rounded protuberance. (Pl. VIII.) Eggs laid outside the parchment are firmly embedded in the new

[a] Since this was written Mr. McLachlan has reported the existence of the same form of protection in Upland varieties in Texas. The following note describes the results of injuries inflicted upon the bolls of a plant of Parker cotton in four days from August 8 to August 12, 1905:

"The 9 larger bolls, when opened, were found to have 28 weevil eggs deposited in them; 6 had struck the dissepiment; 12 were not entirely through the shuck of the boll (either not more than half way there or else stuck in the tough inner tissue of the shuck); the others were embedded in the lint. In only two instances was there any proliferation apparent. The outer shuck had proliferated at the wound and in one case had encysted the egg. The other had merely forced the egg to one side, having begun the development too late."

growth and do not appear to hatch, or if they do the larvæ are not able to do any damage, since they can not penetrate into the interior of the boll. It quite frequently happens that eggs are laid in the sinus or groove between the linings of two locks, but without penetrating the parchment of either. The tissue is here somewhat looser than in other parts of the wall. In a few instances it was observed that the larvæ had hatched, but no case was found which indicated that larvæ hatched outside the parchment lining had been able to penetrate to the interior cavity.

PROLIFERATION FROM THE WALL OF THE BOLL.

The wall of the boll offers an active form of weevil resistance by proliferation, in a manner somewhat analogous to that of the proliferation of the square. The channel excavated by the weevil is closed by the new growth, which continues to push out on the inner surface of the wall in the form of a rounded, blister-like protuberance of loose tissue. This surrounds and encysts the weevil egg, and prevents its development. A section through the mass of new tissue shows the egg embedded in it or pressed against the lint. Proliferation often takes place even when the tough lining of the chamber has not been penetrated, and then appears as a prominence underneath the membrane.

It has been seen from the preceding paragraph describing the thick walls and tough lining that in the Kekchi cotton, at least, the weevil is practically excluded from the boll after the boll has reached about three-quarters of its full size; but even in its younger stages also there is a measure of defense through the formation of new tissue as a result of the irritation set up by the weevil's injuries in a manner analogous to that which induces the formation of galls and other vegetable excrescences.

The first result of the proliferation is to fill up and heal the wound bored out by the weevil. The cavity is not only completely filled, but in most cases a wartlike prominence is formed on the outside, and if the parchment lining or the inner wall has been penetrated the new proliferating tissue also grows through on the inside and often spreads out as a biscuit or button shaped protuberance of soft white or transparent tissue several millimeters in diameter and readily visible to the naked eye. (Pl. VIII.)

There are two alternatives in the fate of an egg destroyed by proliferation. Either it is completely surrounded in the proliferating tissue outside or inside of the parchment wall or it is carried on the apex of the proliferation down against the lint and flattened between the growing surfaces. After the egg has disintegrated and disappeared its position is frequently shown by a minute brown

stain. Such a discoloration often spreads back into the loose tissue and then gradually extends over the whole lock of cotton of that particular chamber. The seeds fail to develop and finally shrivel up.

If the proliferation results, as usual, in the death of the weevil egg or young larva, the process of abnormal growth ceases with the formation of a knob or button of the new tissue on the inside of the wall of the boll. When, however, the young weevil escapes destruction and continues to eat and grow, the proliferating tissue also continues to increase, until in some instances the whole compartment is filled with a silvery-white cheesy material which seems to arise not only from about the original perforation of the outer wall, but also from other parts which have been injured and irritated by the presence of the weevil larva. This, with other facts already stated, seems to show that in some varieties of cotton, at least, the tendency to proliferation is very general, or, in other words, constitutional, which warrants a larger hope of increasing this character and making it uniform by selection.

When proliferation, which results from the presence of the weevil larva, has become very extensive and fills the entire compartment, the weevil larva is sometimes found to have eaten through the dissepiment into the next chamber, perhaps to escape starvation. Such extensive proliferation, accompanied by the failure of the seeds to develop, means, of course, that the weevils gained entrance while the boll was still very young. Moreover, if the boll had been older there would have been plenty of food for the larva without the necessity of entering a second compartment. Finally, the dissepiment would have been too tough for the larva to penetrate easily.

Further proof of the fact that the weevil larvæ are seldom or never able to gain a footing in the larger bolls is to be found in the fact, already stated, that the weevil larvæ found in them are nearly always in undersized compartments, much smaller than those which have remained uninjured, and have thus been able to continue their normal development.

It is to be supposed, perhaps, that if the weevils could gain access to large bolls and feed upon the nearly adult seed they would be able to develop in less time than they usually spend in reaching maturity on the rather poor provender they secure among the abnormal tissues which arise after they have entered the young bolls.

The exclusion of the weevil from the large bolls has been evidently not only an important measure of protection for the cotton, but it has probably compelled the weevil to accustom itself to a gradually longer and less prosperous development in the boll. The development of the weevil-resisting adaptations on the part of the cotton plant has left the insect with two opposite alternatives. It must enter the boll early and submit to a very long period of development

or enter the square late and develop very promptly. The insect ha been able, as we know, to avail itself with a large measure of succes of both these alternatives, but it is not without encouragement fo future progress in weevil resistance to know that the plant has s successfully guarded itself in two parts of its life history.

If additional evidence be needed to show that the food suppl obtained by the weevil larvæ in the bolls is very different from tha in the squares, it is to be found in the large, firm-walled cells of com pacted excrement with which they surround themselves in the boll before reaching maturity. The food being of a much coarser natur and the period of development about three times as long, the amoun of waste material is naturally very much greater. If feeding upo the boll is, as now appears probable, the ancestral habit of the wee vil, it need not surprise us that the protective adaptations of the bol are more numerous and effective than those of the bud, which may have been attacked by the weevil in comparatively recent times.

TIME REQUIRED FOR PROLIFERATION.

In connection with the experiments in Texas, Mr. McLachlan attempted to ascertain the time required for proliferation to take place after the injury had been inflicted. The amount of proliferation and the time required for it to develop may be expected to depend much on external conditions. Squares of Parker cotton showed no development in six hours, but observation on bolls showed that proliferation was complete in twenty-four hours. Two of Mr. McLachlan's observations are described in the following notes:

On August 14, at 9.15 a. m., a wire cage was placed over a plant of King cotton, and four weevils, of which at least two were females, were put inside. Later, three more were introduced. At the time there were 11 bolls, 39 squares, and 1 flower on the plant.

On August 17, at 1 p. m., 11 bolls and 18 squares were picked, a little more than three days being allowed for the weevils to work. There was no rain, and of the 18 squares examined only one revealed proliferated tissue, though the weevils had scarred the buds in more than 33 separate places and had deposited 15 eggs. But the bolls showed better results. They had been scarred at 32 different points, and 23 eggs were discovered when the bolls were cut open. In 12 cases inward proliferation of the "shuck" had destroyed the eggs. Several of the incited growths had caught the egg, encysted it, and carried it along, inclosed at the apex, as they pushed their way into the lint. As in the Parker cotton examined a short time ago, weevils seem to have some difficulty in getting the egg through the shuck of the boll. In dry weather it appears that the King cotton is as backward as the Parker in proliferation in the squares, but in bolls proliferation goes forward as well in dry as in wet weather.

On the 30th of August, at 10.15 a. m., a boll (half grown and tender) was bagged with a weevil. At 6 p. m. of the same day an egg puncture was found on the fruit, but at 8 a. m. of the 31st no further injury had been inflicted. At 12 m., September 1, four more egg punctures were discovered, and the boll was

pulled and examined. The first puncture was then forty-two hours old and the other four some twenty-four hours old. The examination revealed marked proliferation in every case, with no greater growth in that of forty-two hours' duration than there was in that of twenty-four. Eggs had been laid inside the wall of the boll, since it was easy, in the case of young, tender fruit, for the weevil to cut an opening to the lint. But every one of the five eggs had been encysted by the proliferated tissue. It is quite possible that one or two of the punctures reckoned as twenty-four hours old were still more recent.

EFFICIENCY OF ADAPTIVE CHARACTERS OF BOLLS.

The amount of protection afforded in Guatemala by the weevil-resisting characters of the bolls might be greatly underestimated if it were to be supposed that the weevils make numerous attacks upon the bolls for the purpose of feeding upon them.

In their accounts of the habits of the boll weevil in Texas, Messrs. Hunter and Hinds have devoted a chapter to "effects of feeding upon squares and bolls,"[a] but in Guatemala no indications were found that weevils punctured the larger bolls for any other purpose than egg laying. It is true that the outer surfaces of bolls are frequently marked with scars of weevil punctures from which no larvæ have developed and no internal injuries have resulted, but these failures can be explained in other ways than by the supposition that the weevils feed upon the tough and innutritious outer walls of the bolls. In Guatemala, at least, it appears that the weevil scars on large bolls mark attempts at egg laying, though for a variety of reasons already recited most of them are not effective. The only instance where weevils were found feeding in bolls in Guatemala was at Rabinal. Two weevils were together attacking a small boll, and had eaten out large superficial pits, quite unlike the punctures in which eggs are laid.

Feeding punctures in bolls are referred to by Mr. McLachlan in a note dated at Victoria, Tex., August 31, 1905. Such injuries were not found, however, to lead to the formation of external warts which could be mistaken for egg punctures, doubtless for the reason which Mr. McLachlan gives:

It has been noticed that in bolls no proliferation occurs following the injury from a feeding puncture, however serious that may be. Furthermore, from the above and other observations it is apparent that proliferation is not excited by the egg puncture or the egg, unless the puncture extends through the inside tissue and the egg is fixed in the tissue or has been pushed through it to the lint. In that case a dense knob of proliferation occurs on the inner side of the shuck, in the center of which the egg is often encysted. There must be a constant irritant like the egg, with an opening to give it access to the lint, in order to occasion the specialized growth. As a suggestion it might be noted that all the egg punctures are sealed by the adult weevil at the time of egg laying, while the feeding punctures are left open.

[a] Hunter, W. D., and Hinds, W. E., 1905. The Mexican Cotton Boll Weevil, Bul. 51, Bureau of Entomology, U. S. Department of Agriculture, p. 59, Pl. VIII.

The feeding experiment reported by Messrs. Hunter and Hinds[a] shows that weevils fed exclusively upon bolls lived less than twenty days, while those fed upon the squares lived nearly seventy days. The bolls proved to be much less suitable for food than the leaves, on which the weevils were able to prolong life for thirty days and upward, though no eggs were laid on a leaf diet. It may be that in Texas, where the army worms sometimes destroy all the leaves, the weevils might be driven to gnawing the bolls for food, but in Guatemala the plants remain in full leaf throughout the growing season.

BACTERIAL DISEASES FOLLOWING WEEVIL INJURIES.

In the study of the bolls of the Kekchi cotton three diseased conditions were observed, some or all of which may be of bacterial origin, the bacteria having been introduced, perhaps, by the weevils at the time of egg laying. None of these diseased conditions is frequent, and as they do not permit the fruit to reach normal maturity it seems very unlikely that they can be introduced into the United States with the seeds. It may be stated in addition that the seed obtained by Mr. Kinsler in the season of 1905 has been carefully selected in the field and comes from the earliest and most vigorous bolls.

The first of the diseased conditions consists in a white deliquescence of the immature seeds and lint as though the lock had been dipped in milk. There is also a distinct odor of fermentation. Another disease turns the seed and lint brown. Though observed only in bolls which have been punctured by the weevil, there was often an apparent connection between the disease inside and the large extrafloral nectaries. A column of transparent or somewhat discolored tissue extends from each nectary obliquely upward to the cavity of the boll. This may be a symptom of the disease or it may indicate that bacteria find their way into the bolls by way of the nectaries.

The third abnormal condition was also indicated by a brown discoloration of the wall and contents of the affected compartment of the boll. The seeds and lint soon die and shrivel. No special indication of bacterial activity was noted, and it may be that the death of the weevil egg or larva has some prejudicial effect upon the surrounding cells, as suggested by the brown discoloration already noted in describing the effects of proliferation. Such a disturbance might continue to spread and thus cause the death of the young seeds.

BREEDING IN BUDS A DERIVED HABIT.

The fact that the weevil larvæ are found in the young buds of the cotton plant and also in the full-grown bolls has been taken to mean that it affects all the intervening stages as well. This would imply

[a] Hunter, W. D., and Hinds, W. E., l. c., pp. 34–35.

also that if the weevil fed originally upon the bolls it has followed back to earlier and earlier stages and finally to the bud. The facts already detailed seem to prove, however, that this is not the case. The weevil does not attack the very young bolls, nor does it operate while the flower is open or while it remains in place, though in a withered condition. The hatching of the weevil larva in the large buds is likewise ineffective because the larva is deprived of shelter when the flower opens. It seems necessary to believe, therefore, that the parasitism of the weevils upon the buds of the cotton is a habit quite distinct from that of its relations to the boll. The habit of breeding in the bud marked a new departure in the biological history of the insect and not a gradual change from the previous habit of infesting the bolls only. Nevertheless, the change of habits need not be thought of as anything very remarkable from the standpoint of the insect. A cotton bud is very much larger than a small boll. The peculiarity lies in the plant rather than in the insect, since very few plants afford a continuous and abundant succession of large, pollen-filled buds. It is this quality of the cotton plant which has enabled the weevil to develop its peculiar and highly destructive secondary habits of feeding upon the buds and using them as breeding places. If the boll weevil were restricted, like related beetles, to parasitism upon the fruit of the cotton, it would have remained a comparatively harmless and agriculturally insignificant enemy. These considerations may assist in a better appreciation of the extent to which the weevil's power of injury would be diminished if we could obtain a variety of cotton with a fully determinate habit of growth, one which would cease producing buds as soon as a crop of cotton had been set.

The much more rapid development of weevil larvæ in the bud is to be connected, doubtless, with the much richer food offered by the mass of pollen, but it may represent also a somewhat more definitely adaptive specialization of the life history of the weevil, for it is generally a question of eating the pollen promptly or not at all. If the bud falls off on moist ground the pollen would be completely decomposed long before the larva could develop, at the rate at which it grows in the boll, and if the bud did not drop off, but continued to grow, the flower would open and turn the larva out. It is obliged, therefore, to do damage fast enough to keep the flower from opening, and must then eat the remaining pollen before it spoils and leaves the larva too hungry and stunted to pass through the final metamorphosis into the adult stage. In a cotton which has a highly developed habit of shedding the injured buds it would not be so necessary for the larva to attack the pistil. It may be that this policy on the part of the weevils in Guatemala has a use to the weevil as being necessary to prevent the opening of the flower and cause the falling of the bud.

The diversity in size of the boll weevils, while not unprecedented among insects, is unusual, and not without biological significance in the present connection. An explanation of the variation in size is to be found, no doubt, in the varying amounts of food which the weevil larvæ can obtain, but there is needed, none the less, a special adaptability on the part of the weevil to permit it to reach a normal reproductive maturity in spite of very unfavorable conditions. The smaller weevils probably have less than a quarter of the weight of the large ones, which means that they are able to develop with a correspondingly small proportion of the food required to raise a full-sized weevil. The weevils developed in the bolls have a much greater uniformity of size. The small weevils are at once a means and a result of the acquisition of the habit of living in the buds, and especially in the small ones, where the supply of food is often very small.

RELATION BETWEEN PROLIFERATION IN BUDS AND IN BOLLS.

The analogy of the mucilaginous tissue found in the young fruits of okra and other relatives of the cotton would lead us to expect that proliferation could occur more readily in the boll than in the bud, which may mean that all the varieties which proliferate in the bud will do so in the bolls as well.

It was at first supposed that if the buds proliferated but not the bolls the result would be merely a postponement of the breeding season of the weevil for two or three weeks, or until the bolls had time to develop. Such a delay would be of great practical importance in retarding for that length of time the effective breeding period of the weevils. Moreover, most of the eggs of the weevils which had passed through hibernation would be lost by being laid in the buds, which would further keep down numbers in the early part of the season. There is, however, the further and still more important consideration, that the period of development of the weevil in the boll is very much longer than required for it to mature and emerge from the square.[a]

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[a] Determinations of the length of the life cycle in bolls have been made only in a few instances. In 7 cases between August 15 and November 11, 1903, the average time required from the deposition of the egg to the escape of the adult from the opening boll was sixty-one days. The average effective temperature for the period was 31.7° F., and the average total effective temperature required for development in bolls was therefore 1,933.7° F., or nearly two and one-half times as much as in squares. Several larvæ often develop within a single boll. They appear to remain in the larval stage until the boll becomes sufficiently mature or so severely injured as to begin to dry and crack open. When this condition of the boll is reached, pupation takes place, and by the time the spreading of the carpels is sufficient to permit the escape of the weevils they have become adult.—Hunter, W. D., and Hinds, W. E., The Mexican Cotton Boll Weevil, Bul. 45, Division of Entomology, U. S. Dept. of Agriculture, 1904, p. 75.

Moreover, it seems that the adult weevil does not come out through the wall of the boll, but waits to be liberated when the boll opens to maturity. This would mean that if proliferation can exclude the weevil from breeding in the squares it would afford a practical solution of the problem, since instead of merely delaying the emergence of the first brood of weevils for two or three weeks, none of them would be able to set about the work of destruction until the crop had begun to ripen, and all danger of appreciable damage would have passed. It seems, therefore, that the proliferation in the squares is the much more valuable characteristic to be considered in seeking for a weevil-resistant cotton. Proliferation in the bolls is very desirable, but the absence of it should not be allowed to figure very largely against a variety which might have a pronounced tendency toward proliferation in the bud. Nevertheless, other factors must enter the calculation, for thin-walled bolls might allow the weevils to escape earlier. In moist weather the bolls might not crack open, but give the weevils comfortable shelter all winter, as would seem to have been the case in the spring of 1905, when various observers noted that some of the weevils seemed to have the appearance of having emerged only recently from the pupal condition, their very light color showing that their outer covering of scales was still in place.

The probability is, however, that the proliferation in both places will be found to depend upon the same internal factor or quality, so that it will be safe to assume that a high degree of proliferation in the bud could be taken as an index of what might be expected from the bolls. This would simplify the problem of selection by permitting us to confine our attention to the buds.

PROTECTION OF SEEDS BY LINT.

Like the large leafy involucre, the lint is also a peculiar feature of the cotton plant which may prove to have a practical connection with the weevil. Cotton is the only food plant of the boll weevil, and only the cotton, of all the related plants, has an abundant provision of lint. Some of the species of Hibiscus have the seeds slightly silky, but the cotton stands quite alone in the length and abundance of the hairy covering which grows out from the seeds at the time the bolls are most subject to weevil injuries.

From the standpoint of those who believe that all characters are useful to the organisms which possess them, the interpretation of the lint as a weevil-resisting adaptation will not appear unreasonable, since it can scarcely be claimed that there is any other use of the lint so important to the plant as protection of the seeds from the weevils. In other respects the lint seems rather a disadvantage than other-

wise. In a humid tropical country the seeds, if left to themselves, remain inclosed in the tangled mass of lint and usually rot. Birds might carry the lint away to build nests, and in so doing might assist in scattering the seeds, but in most of the varieties the seeds are to be detached only with difficulty.

Composed as it is of nearly pure cellulose, the lint can afford very little nourishment, even in the younger stages. Between the lint and the watery proliferating tissue the weevil larva must find the inside of a cotton boll a very inhospitable place unless it can penetrate to the seeds. Dead and moribund larvæ are occasionally found in these unfavorable situations. And even the seeds themselves do not provide so favorable a food as the pollen, as shown by the much longer time required by the larvæ to develop in the boll than in the square.

PROTECTIVE SEED ARRANGEMENT IN KIDNEY COTTON.

Further intimation of the protective value of the lint is to be found in the very peculiar Kidney cottons, so called because the seeds are crowded together in the central angle of the chamber and adhere firmly to each other, thus forming a small, kidney-like mass. This unique arrangement brings all the lint to the outside of the seed, and may be the explanation of the fact that the Kidney cottons are the only representatives of the Sea Island type which have gained a wide distribution on the mainland. The separate-seeded Sea Island cottons came from Barbados, where the boll weevil did not exist and has not yet been introduced. (See Pl. X, fig. 2.)

The outer wall of the boll of the Kidney cotton is notably thinner than that of Kekchi cotton, so that the beaks of the weevils could reach through without difficulty. But with the layer of lint to supplement it the wall becomes, for practical purposes, much thicker than in the free-seeded varieties. The inner parchment lining is rather tough, though apparently less so than in the Kekchi cotton.

The Indians about Trece Aguas, Guatemala, are said to recognize the weevils as enemies of the dwarf cotton, but it is the local opinion that the Kidney cotton is proof against them.

No weevils were found on the two bushes of Kidney cotton examined in that locality, but these were single plants growing near Indian houses several miles away from the nearest field culture. In a forest-covered country like this part of Guatemala the luxuriant and tangled vegetation may well impede the flight of such an insect as the weevil. And if it lives, as supposed, only on cotton, its chance of reaching a single bush of tree cotton would be very small. That the buds and young bolls of the Kidney cotton are able to offer any absolute resistance to the weevil seems very improbable, and the abundance of weevils found on the large tree of Kidney cotton at Tucuru last year proved that the immunity, if any, is not general.

The Kidney cotton, though commonly treated as a distinct species under the name *Gossypium peruvianum*, agrees with the Sea Island type in all its characters except the peculiar arrangement of the seeds. If this should prove to be an adaptive feature the idea of specific distinctness would have little left to support it.

CULTURAL VALUE OF KIDNEY COTTON.

The possession by the Kidney cotton of a definite weevil-resisting adaptation would naturally raise a question regarding its cultural value. It belongs to the Sea Island series, and has the long, fine fiber and smooth seeds. The growing of the seeds together in masses would still further facilitate picking and ginning operations. The bolls, too, of this Guatemalan Kidney cotton, at least, are larger than those of any of the Sea Island varieties.

It is not likely, however, that any of the varieties of Kidney cotton thus far known will be found of use in the United States, for all are perennial "tree cottons," which have refused thus far to flower or fruit in the period of growth allowed by the shorter summers of our Temperate Zone. In tropical regions this objection would not hold, and there appears to be no reason why the Kidney cottons should be disregarded in the search for varieties suited to the various soils and climates. The Trece Aguas Kidney cotton, for example, seems to thrive well in a humid mountain climate considered by the natives to be unfavorable for the annual Kekchi cotton, which is planted several hundred feet lower down.

THE NATURE AND CAUSES OF ADAPTATIONS.

To explain how such characters as the weevil-resisting adaptations arise involves an interpretation of general evolutionary questions upon which the scientific world is still by no means agreed. Nevertheless, it is evident that students of such subjects should conduct and describe their investigations in accordance with some consistent plan or policy, if their writings are to be understood or their facts intelligibly recorded. Moreover, it would be scarcely reasonable to maintain that such characters can be further increased by selective influence unless it could be believed that they had been assisted in the past by the same agency.

It seems necessary to state that in the present report it is not assumed that the weevil-resisting characters have arisen as direct protective responses to the injuries, or that they are the results merely of stimulation or irritation caused by the weevils, as other writers on evolutionary subjects might hold. Nor have they been thought of as caused by selection in any strict sense of the word. Though constituting a most striking instance of the results of selective influence, it

is believed that the cotton plant must first have originated in some measure the protective characters before the external conditions (in this instance, the weevils) could make them of advantage to the plants and thus encourage their further development.

The older theory that environment and natural selection are the efficient or actuating causes of evolutionary change has lost many adherents in the last decade, especially among those who found themselves unable to credit any longer the idea that all the characters and differences of plants and animals are, or have been, of use to them. It has been shown, too, by Professor Weissman and his followers, that direct adaptations or responses of individual organisms to the environment are seldom or never inherited by their offspring. To take the place of the doctrine of direct environmental influence in evolution it has been suggested that there may be an internal "hereditary mechanism," as it has been called, which determines adult characters in advance, in the reproductive cells, so that modifications of the specific or varietal type can arise suddenly. Selection would determine, of course, which of such new "mutations" should survive, but it would be a mere accidental coincidence if the new character happened to fit the conditions better than the old.

It is possible, however, to explain evolutionary progress and selective adaptations without ascribing them either to external causes or to theoretical internal mechanisms. The diversity which plants or animals of the same parentage often show under the same conditions makes it evident that there is no precise mechanism which determines their form in advance, and all attempts at securing any absolute uniformity or "fixity" of form and color have failed. The fact is that organisms, even of the same species or variety, are normally diverse, and must have ancestry mixed by interbreeding if bodily vigor is to be maintained for any great number of generations.

The generalized "specific type," which is a product, as it were, of this diversity and interbreeding, is constantly and gradually changing, and in many ways at once, though in some characters more rapidly than in others. Selection, while in no strict sense a cause of this vital motion of the species or variety, may profoundly influence the direction and rate of change. Selection, in other words, explains adaptation, but does not explain evolution.[a]

The word adaptation is used in more than one sense by writers on biological subjects. Some treat as adaptations the changes of form or structure by which many plants and animals are able to conform to the needs of different conditions. There are several plants, for example, which have normal broad leaves when they grow on land, and very narrow and much-divided leaves when they grow submerged

[a] Natural Selection in Kinetic Evolution, Science, N. S., 19:549. 1904.

in water. Some plants are hairy in dry localities, but are nearly naked in humid districts. Others treat these direct responses to external conditions under the heading of accommodation, and reserve the word adaptation for characters which appear regularly in a species or variety, but which fit it for some special condition, such as that presented to the cotton plant by the boll weevil. It has seemed proper, therefore, to discuss as protective adaptations any characters which seem to give the Central American varieties an advantage in withstanding the attacks of the weevil, particularly if it can be shown also that the presence of the weevil would tend to the preservation and extension of the given character.

In the strict sense of the words, the weevil-resisting adaptations of the cotton plant would include only those characters which have been increased by the selective influence of the boll weevil, but in the broader practical sense we may treat as a weevil-resisting adaptation any feature which tends to limit the destructiveness of the insect.

The adaptive nature of some of the characters of the Central American varieties discussed in the present paper is reasonably obvious, but in other instances extended studies in developmental biology and primitive agriculture might be necessary to determine the origin and development of a varietal characteristic which may have significance in the weevil problem.

It is easy to understand that so injurious an insect as the boll weevil has exerted a definite selective influence ever since its remote ancestors turned their attention to the cotton. Perhaps its earlier food plants were completely exterminated. The nearest living relatives of the cotton are the species of Hibiscus, Paritium, and Thespesia, none of which is known to have any attractions for the weevil. It is evident, too, that in the presence of the weevil the cotton plant would have met long ago a like fate if it had not been able to take on its various adaptive characters. That so many of the features by which it differs from its nearest relatives have such obvious connection with the weevil would certainly justify the belief that strong adaptive influence had been at work, even if the other circumstances were unknown.

In thinking of the relation between two organisms like the weevil and the cotton we often fall into the error of too great humanizing, so to speak; that is, we ascribe too great intelligence or too complete a reaction to cause or conditions. Thus the weevil, although highly specialized in some of its instincts, has, of course, no equivalent for the human judgment. It will puncture, as already seen, buds much too small to raise a larva, and will lay its eggs in the rind of the boll, where the larvæ can never develop. If the conditions are too favorable to the weevil, as in humid regions, it would undoubtedly exter-

minate its own host plant by permitting the cotton to produce no seed. Paradoxical as it may at first seem, we may, nevertheless, believe that the best conditions for the perpetuation of the weevil are those which are not altogether favorable to its unlimited multiplication.

CONSCIOUS AND UNCONSCIOUS SELECTION.

There are two principal ways in which improved varieties of cotton and other cultivated plants come into existence. The first is by sudden or abrupt changes, or sports; also called mutations, saltations, and discontinuous variations. These are represented in cotton by the occasional appearance of a plant with brown lint,[a] deeply divided leaves[b] (okra cotton) or very short branches (cluster cotton). The Guatemalan varieties represent a second type of evolutionary history, in which improvement is accomplished by more gradual progressive change, fostered and accelerated by selection.

Two forms of selection are commonly recognized, natural and artificial, the latter effected by man, the former by circumstances of the environment. This distinction is of doubtful value in any case, and quite obscures the important point in the evolutionary history of cotton and other plants domesticated by primitive man. It would be much better to think of selection as either conscious or unconscious, and between these two a very practicable difference exists. Conscious selection implies the preservation of individuals having a desired quality in the highest degree, while unconscious selection, whether by man, animals, or inanimate conditions, means merely the rejection of the most unfit, so that the improvement of the species or variety is gradual. Conscious selection acts, of course, much more

[a] In Guatemala several tribes of Indians prefer brown cotton, and for certain garments use brown cotton only. Separate plantings of brown cotton are not made in the neighborhood of Secanquim, where our experiment was located, but there were said to be such at Cajabon and Lanquin, only a few leagues away. The Cajabon people have a dark-brown cotton called "canch nok," and a lighter brown called "canni nok."

On the Pacific slope Mr. William R. Maxon found considerable culture of a brown cotton called "ixcaco." At Antigua a similar brown variety is said to have been grown formerly in considerable quantities, the common name of which is "cuyuscate." It was not learned that any special religious use or significance is attached to brown cotton in Guatemala, as is said to be the case in Peru and in India.

[b] Some may be inclined to interpret these as reversions and to argue that the deeply divided involucral leaves may be a reminiscence of an ancestral character of the cotton. Or it may be that the divisions attained by the involucral leaves represent a tendency of specialization which the remainder of the leaves sometimes share by mutation, in accordance with the principle of translocation of characters recently formulated by Dr. R. G. Leavitt (Contrib. Ames Bot. Lab. No. 3).

speedily than unconscious, but is subject to the serious danger of weakening its protégés by inbreeding, if the selection be too rigid and persistent.

The unconscious selection by which the development of the protective characters of the Guatemalan types of cotton has been encouraged differs in no respect from the progress by which adaptive evolution takes place in nature. The Indians have planted and harvested the crop, it is true, instead of the birds or other natural agents, but they have been entirely unconscious of the struggle for existence to which the cotton plant was being subjected by the presence of the boll weevil. The Indians were only another factor, along with the dry and moist climates, the keleps, and the turkeys. The problem has been solved in a genuinely natural fashion, and affords an excellent illustration of the nature of selective influence in evolution.

Instead of representing the final possibilities of improvement in characters which give protection against the boll weevil, the Indian varieties of cotton may be looked upon rather as affording materials which conscious selection can render still more valuable. The proliferation character, for example, might never be brought to uniform expression by unconscious selection, because the possession of it would give the individual plant no advantage over its neighbors in the production of seed. The proliferating plant might produce no weevils itself, but the free movement of the insects would keep the general average the same. Indeed, a plant might easily sacrifice all its buds, set no fruit at all, and thus fail to perpetuate itself. Proliferation can become a direct advantage to the individual plant only under conscious selection. The full value of the newly ascertained protective adaptations will not be known until they have had the direct selective encouragement now commonly accorded to desirable characters of other cultivated plants.

It may appear remarkable that such definite and potentially valuable characters as the weevil-resisting adaptations of the Kekchi cotton should have remained so completely unrecognized hitherto. The explanation of this doubtless lies in the fact that cotton culture is practiced in Central America largely by the Indians and very little by the foreigners or the more intelligent part of the native community, so that it had not received scientific study. Even the existence and utility of the keleps, though apparently known to the Indians from ancient times, had entirely escaped the attention of the European residents of the country. That the Indians should have come to recognize the keleps as beneficial and necessary to a full crop of cotton, although not knowing that the weevils injure the cotton or that the keleps eat the weevils, only shows in higher relief the completely unconscious character of the selection conducted in this system of primitive agriculture. The Indians of Alta Vera Paz are extremely

stolid, uncommunicative people, from whom little information is likely to be obtained except as replies to direct questions. Familiar from their earliest childhood with the agricultural lore of their own tribe, it does not occur to them that these everyday incidents can be of interest to the white stranger, or if they perceive his interest they learned long since to fear it as a danger of further intrusion. Even our own cotton experiments were misunderstood as a menace of additional demands for lands from the white men who now own so large a part of the country.

SUMMARY OF ADAPTATIONS.

If the facts stated in the present report have been correctly observed and interpreted, we must admit that the cotton plant is in a high state of adaptive specialization in its relations with its now famous insect enemy, the boll weevil. Indeed, it may be that the most distinctive and important characters of the plant, from both the botanical and the agricultural standpoints—such as the involucre, the nectaries, the oil glands, the large bolls, and the very lint itself—are adaptive features which the selective influence of the weevil has brought to their present degree of development.

CLASSIFICATION OF ADAPTATIONS.

The adaptations of the cotton plant might be summarized from three different standpoints. A historical treatment would proceed from the adaptations of the bolls to those of the buds. Breeding in the buds, for instance, was evidently a later adaptation on the part of the weevils which has called for a second set of the protective characters on the part of the plant.

It may be better, however, to classify the adaptations as such, without special regard to their historical sequence of derivation. The more practical purposes are served by dividing the adaptations into four groups: (1) Those calculated to avoid the weevils by general habits of growth; (2) those which exclude the weevils, or at least hinder their operations in the buds and bolls; (3) those which attract insect enemies such as the weevil-eating kelep; (4) those which prevent the development of the weevil larvæ, even after the eggs have been laid.

ADAPTATIONS TO AVOID WEEVILS.

1. Determinate growth.
2. Early bearing.
3. Long basal branches.
4. Early rejection of superfluous squares.
5. Seasonal bearing of perennial varieties.
6. Prompt bearing after cutting back.
7. Hairy stalks and leaf stems.
8. Pendent bolls.
9. Rapid growth of young bolls.

ADAPTATIONS TO EXCLUDE WEEVILS.

1. Involucral bracts grown together at base.
2. Closely appressed margins of involucral bracts.
3. Margins of involucral bracts strongly laciniate and hairy.
4. Unusual size and width of involucral bracts.
5. Calyx produced into slender hairy laciniæ.
6. Persistent flowers.
7. Oil glands (?) of very young bolls.
8. Thick-walled bolls.
9. Tough linings of boll chambers.

ADAPTATIONS ATTRACTIVE TO THE KELEP.

1. Nectaries of leaves.
2. Large outer nectaries of involucre.
3. Large inner nectaries of involucre.
4. Bractlets subtending inner nectaries.
5. Continued secretion of nectar.
6. Hairy stalks and leaf stems.
7. Dwarf, compact habits of growth.

ADAPTATIONS TO PREVENT DEVELOPMENT OF WEEVIL LARVÆ.

1. Shedding of weevil-infested buds.
2. Proliferation of internal tissues of buds.
3. Proliferation from the walls of the bolls.
4. Absence of oil glands over dissepiments.
5. Growth of lint on seed.
6. Compacted seeds (Kidney cotton).
7. Lint confined to outer end of seed (San Lucas Sea Island cotton).

ADAPTIVE CHARACTERS OF DIFFERENT TYPES OF COTTON.

The third standpoint for viewing the adaptive characters is that of the different types of cotton. All varieties share, to some extent, the older adaptive features, but the special characters are accentuated in different degrees in the various types. Our study has been directed toward the Kekchi variety, both on account of its relation to the keleps and because it has seemed to possess by far the largest series of adaptive features. But now that the existence of adaptations of practical value has been ascertained it will be necessary to canvass the field thoroughly.

ADAPTATIONS OF KEKCHI COTTON.

An enumeration of the adaptations of the Kekchi cotton is scarcely necessary, because that variety has nearly the whole series and most of them in a more accentuated form than the other types thus far studied. The few exceptions are noted below.

ADAPTATIONS OF RABINAL COTTON.

1. Prompt bearing after cutting back.
2. Very hairy stalks, leaf stems, and involucral bracts.
3. Closely appressed margins of involucral bracts.
4. Involucral bracts grown together at base.

ADAPTATIONS OF PACHON COTTON.

1. Involucral bracts margined with stiff laciniæ and bristles.
2. Calyx large, the divisions slender and hairy.

ADAPTATIONS OF SAN LUCAS SEA ISLAND COTTON.

1. Definite seasonal bearing.
2. Lint confined to outer half of seed.
3. Proliferation in buds.
4. Proliferation in bolls.

ADAPTATIONS OF KIDNEY COTTON.

1. Definite seasonal bearing.
2. Seeds compacted at center, covered with thick layer of lint.

ADAPTATIONS OF UPLAND COTTON.

1. Shedding of weevil-infested buds.

This is the only weevil-resisting character in which the Upland varieties excel the Kekchi cotton, but, as already explained, the habit is of practical use only in dry climates. The Upland cottons share, however, a large number of the adaptations, though in a less degree than in the Kekchi. Thus there is proliferation both in buds and in bolls, the stems and petioles are somewhat hairy, the habit of growth is somewhat reduced from the tree-cotton stage, the nectaries are often large and active, the involucral bracts are sometimes well folded together, etc.

And now that the possibility of weevil resistance has been shown, variations may be found in all probability among our United States varieties which will enable weevil-resisting strains of the Upland sorts to be developed. At this stage of the inquiry it is too much to hope that the Kekchi type will prove to be adapted to the wide diversity of conditions to be found in the cotton belt. Either the Kekchi or the native cottons, or both, are likely to require extensive modification before the full value of the weevil-resisting adaptations can be realized.

CONCLUDING REMARKS.

The protection afforded by the weevil-resisting adaptations is most effective at the two ends of the period of development, but continues in varying degrees from the young bud to the ripe boll. Under favorable conditions an extremely small proportion of the weevil eggs develop to maturity. Instead of a single attack being fatal to a bud or boll, the same fruit at its different stages may resist numerous punctures and egg-layings. The young bud is protected for a time by the closed involucre. After the weevils have gained entrance the first egg, and often the second or third, may be rendered harmless through the proliferation of the bud in its younger stages. Proliferation becomes less certain as the bud increases in size, but if egg laying be delayed a few days too long the development of the larvæ

is rendered impossible by the opening of the flower. Then ensues another period of immunity while the withered flower remains in place and while the bolls are still too small to be attacked. Between about the quarter and the three-quarter size the bolls can still be parasitized, though proliferation reduces the successful attempts to a very small percentage. But after the lint has grown out, the lining has hardened, and the walls have become thick, the boll is well-nigh impregnable, though the surface may be roughened by a dozen or a score of warts, which mark the location of as many persistent but ineffectual attempts to gain entrance.

As an instance of adaptive specialization the cotton plant seems destined to a very high rank. The development of such a series of protective characters can scarcely be explained except upon the supposition that the culture of cotton in Guatemala is extremely ancient, and of this there are many other indications.

The practical utilization of these protective characters in the cotton industry of the United States may require the solution of many preliminary problems of acclimatization and adaptation, as well as of physiology and cultural methods. The proliferation characters, for example, appear to be much more pronounced in some varieties than in others, but they are also affected, probably to a very considerable extent, by conditions of climate or soil which check the growth of the plant or cut down its water supply and thus reduce the normal turgidity of the tissues.[a]

The weevil-resisting characters are much more highly developed in the variety of cotton cultivated by the Kekchi Indians of eastern Guatemala than in any other type yet known, and it produces also large bolls and lint of good length and quality, so that it may be of value in the United States. But even though the Kekchi cotton in its present form should prove, for any reason, not to be adapted to cultural conditions in the United States, it demonstrates, at least, the fact that the Upland type of cotton is capable of assuming other characters which will render it far better adapted to cultivation in the presence of the boll weevil than the varieties hitherto grown in the United States.

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[a] That the transfer to Texas will not destroy the proliferating habit of the Kekchi cotton is shown by the following report from Mr. McLachlan:

"On the 23d of August Mr. Kinsler and I made a comparative examination of four varieties of cotton at Mackay, Tex., to determine the nature of their proliferation. Rows of Kekchi cotton from Secanquim and Lanquin, and two of native Upland varieties (Parker and King) were compared. The results, in brief, are that in squares the Kekchi cotton proliferated much more readily than did the native varieties. In the bolls all four varieties were about equally active in this protective adaptation. The extent of proliferation in the Guatemalan bolls was, if different in any way, somewhat greater than in the native varieties."

No end is in sight of the new problems and adjustments of cotton culture occasioned by the invasion of the weevils, and no assurances can be given in advance regarding the utility of the weevil-resisting adaptations, any more than with the kelep, or so-called "Guatemalan ant." Both have a present value, however, in proving that the weevil is no invulnerable dragon which it is hopeless to resist. Instead of having no enemies, as long supposed, the weevil is regularly preyed upon by the active and efficient kelep. And instead of there being no remedies which can be used against the weevil, it is now found that the cotton plant itself has a whole series of weevil-resisting characters—a whole boll weevil armory, as it were, from which we may select and sharpen the weapons which prove best suited to our purposes.

The weevil period of each year, that in which the damage is done, extends from the time when the squares are large enough for egg laying to the period when a full crop would normally be set. If the value of the cotton crop be divided by the number of days of this period, the result will show the value of each day of protection. It has been estimated by Mr. W. D. Hunter that the boll weevil damaged the cotton crop in 1904 to the extent of $20,000,000. It is therefore a very conservative estimate that when the pest shall have spread over the other cotton-growing States the damage will be well beyond a million dollars a day for the growing season—in unfavorable years probably two million dollars or more a day. Each day of protection which can be secured by the utilization of weevil-resisting adaptations will have, therefore, very definite and considerable value, so that the study and perfection of this group of characters are sure to be the objects not only of formal scientific study on the part of specialists but of general interest and consideration on the part of the practical cotton-growing public.

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PLATES.

DESCRIPTION OF PLATES.

PLATE I. (*Frontispiece.*) Valley at Secanquim, Alta Vera Paz, Guatemala, the scene of experiments with weevil-resisting cotton.

PLATE II. Fig. 1.—Mature plant of Kekchi cotton, to show small size and determinate habits of growth, compact foliage, and long basal branches. Fig. 2.—Plant shown in figure 1, opened to show numerous large bolls and habit of fruiting on basal branches.

PLATE III. Involucres of Kekchi cotton, opened to show external and internal nectaries, bracts, and bractlets. (Natural size.)

PLATE IV. Fig. 1.—Involucres of Rabinal cotton, showing connate and closely appressed involucral bracts. (Natural size.) Fig. 2.—Open involucres of Egyptian cotton. (Natural size.)

PLATE V. Fig. 1.—Young buds of Kekchi cotton, showing numerous weevil punctures. The buds were split in half so that the full number of punctures could be seen. (Natural size.) Fig. 2.—Buds of Kekchi cotton (same as fig. 1), showing successful proliferations. (Natural size.)

PLATE VI. Large buds of Kekchi cotton, the distortion indicating proliferation. (Natural size.)

PLATE VII. Weevil-infested bolls of Kekchi cotton, showing larger number of punctures along the middle line of the carpel, where the oil glands are absent. (Natural size.)

PLATE VIII. Carpels of Kekchi cotton, showing method of proliferation. (Natural size.)

PLATE IX. Fig. 1.—Kekchi cotton, successive stages of the boll. Fig. 2.—Kekchi bolls (right); King bolls (left), to show comparative size. (Reduced to about one-half natural size.)

PLATE X. Fig. 1.—Rabinal cotton, showing foliage, connate bracts, and weevil-infested bolls. (Reduced.) Fig. 2.—Bolls and seeds of Kidney cotton, showing oil glands and protective arrangement of lint and seeds. (Reduced.)

FIG. 1.—MATURE PLANT OF KEKCHI COTTON.

FIG. 2.—KEKCHI COTTON PLANT WITH BOLLS.

INVOLUCRES OF KEKCHI COTTON, SHOWING NECTARIES AND BRACTLETS.

(Natural size.)

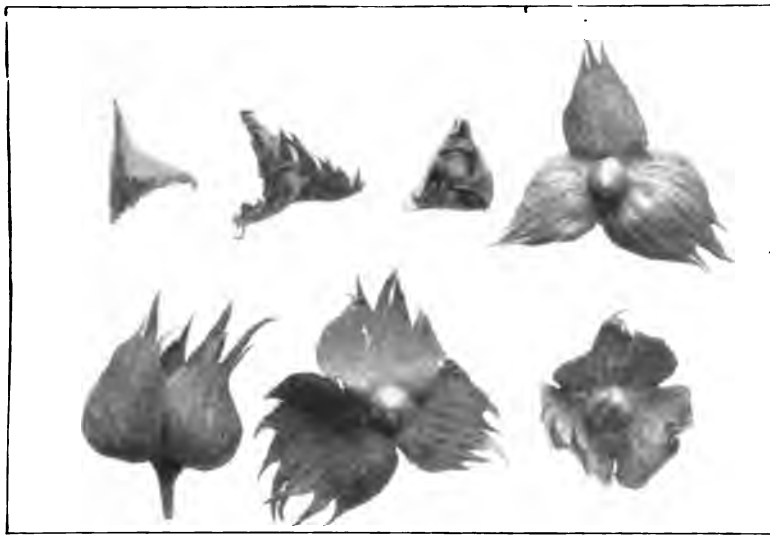


FIG. 1.—INVOLUCRES OF RABINAL COTTON, SHOWING CONNATE AND APPRESSED MARGINS.

(Natural size.)

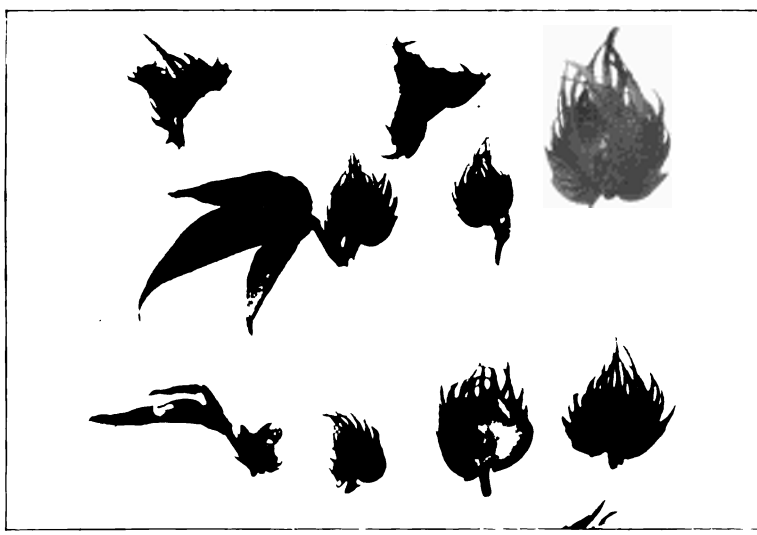


FIG. 2.—OPEN INVOLUCRES OF EGYPTIAN COTTON.

(Natural size.)

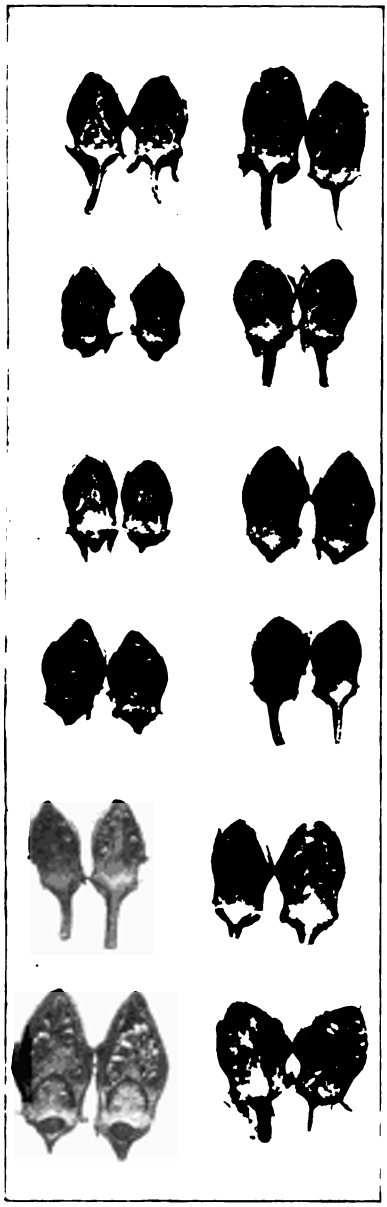


FIG. 1.—YOUNG BUDS OF KEKCHI COTTON WITH WEEVIL PUNCTURES.

(Natural size.)

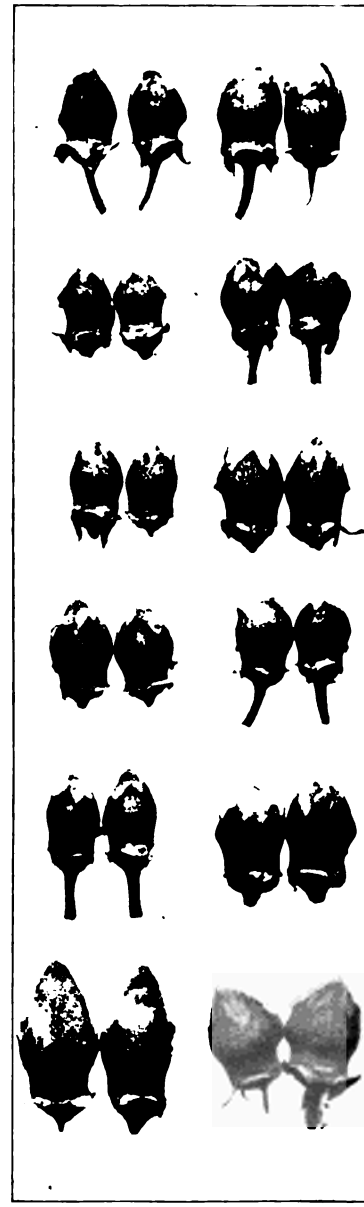
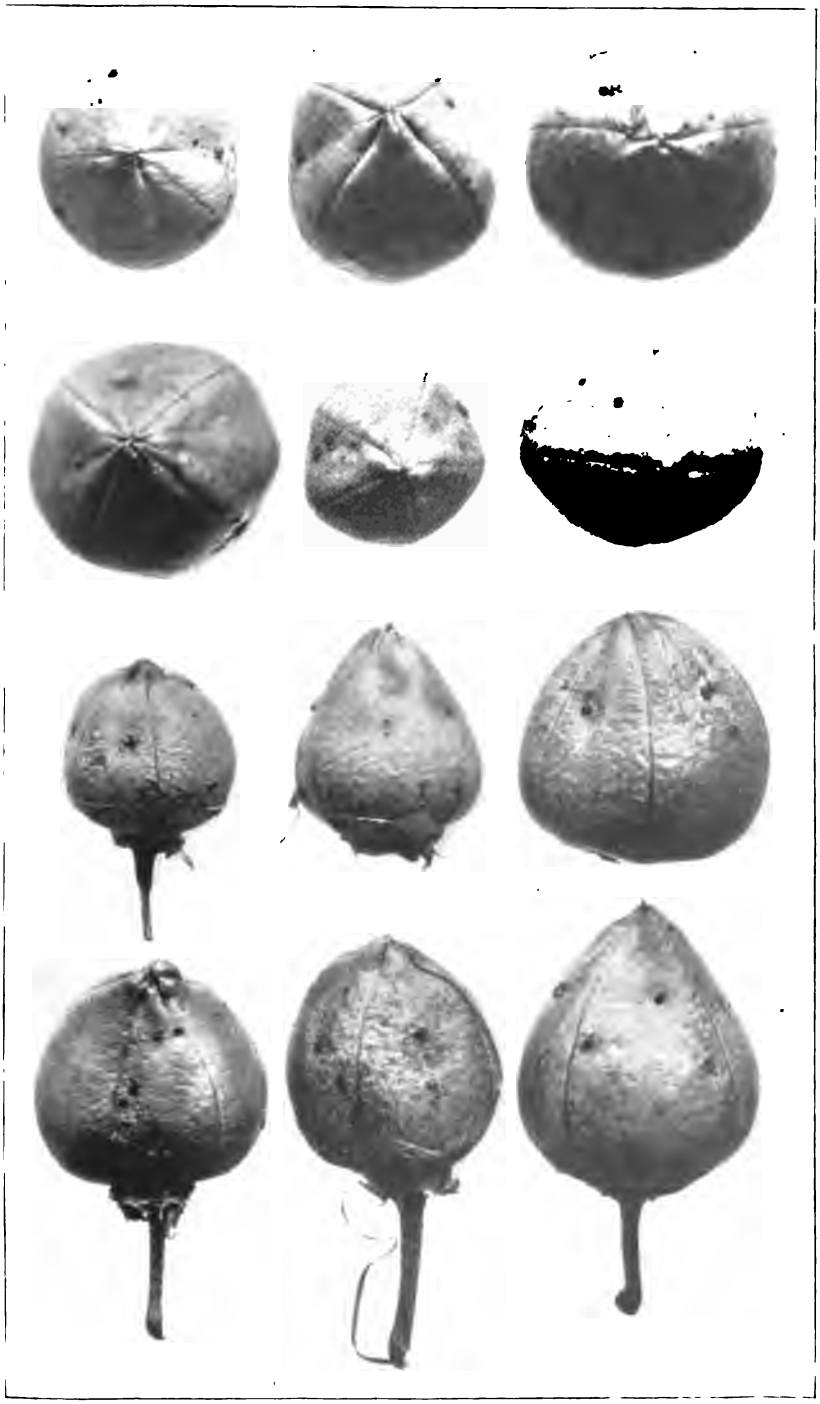


FIG. 2.—BUDS OF KEKCHI COTTON WITH PROLIFERATION.

(Natural size.)

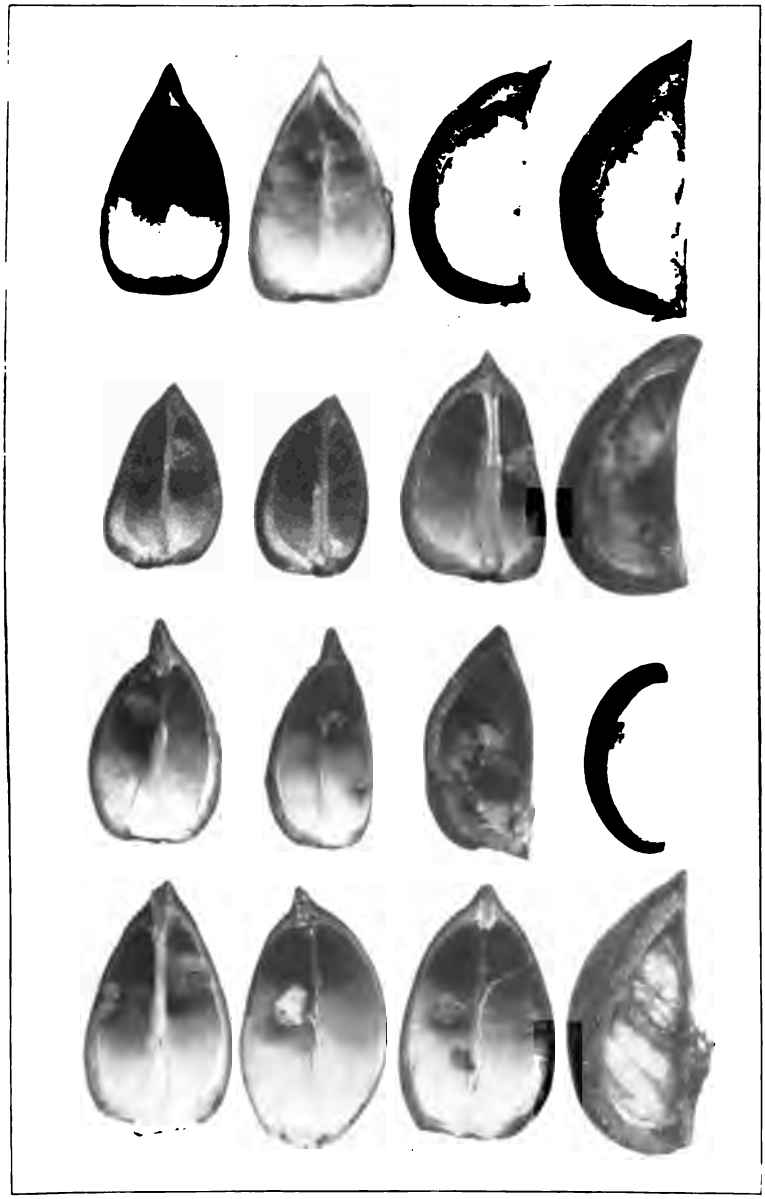
LARGE BUDS OF KEKCHI COTTON WITH PROLIFERATION.

(Natural size.)



WEEVIL-INFESTED BOLLS OF KEKCHI COTTON.

(Natural size.)



CARPELS OF KEKCHI COTTON, SHOWING PROLIFERATION.

(Natural size.)

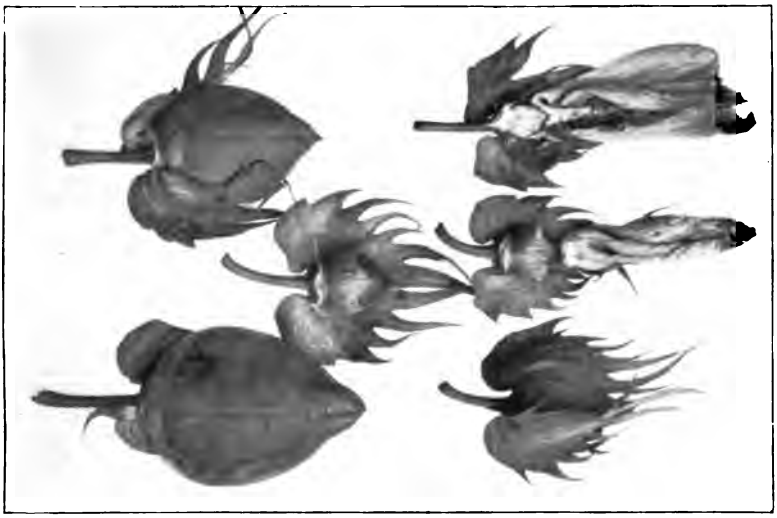


FIG. 1.—KEKCHI COTTON, SUCCESSIVE STAGES OF THE BOLL.
(Reduced.)

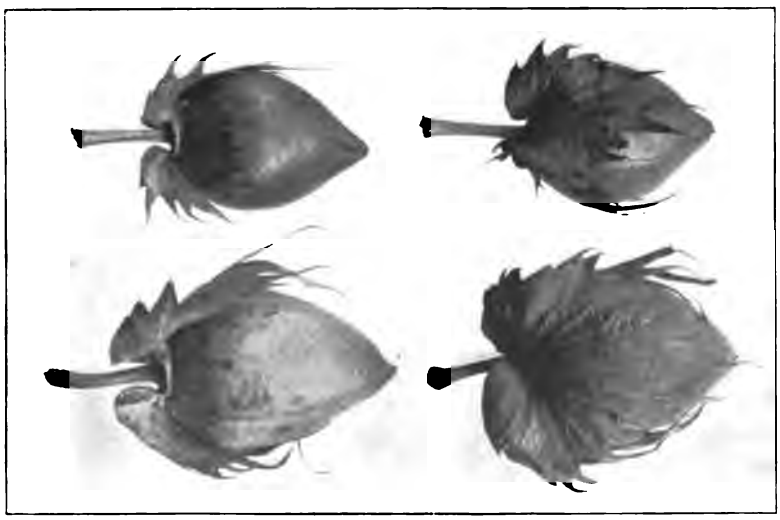


FIG. 2.—KEKCHI COTTON BOLLS (RIGHT) COMPARED WITH KING BOLLS (LEFT).
(Reduced.)

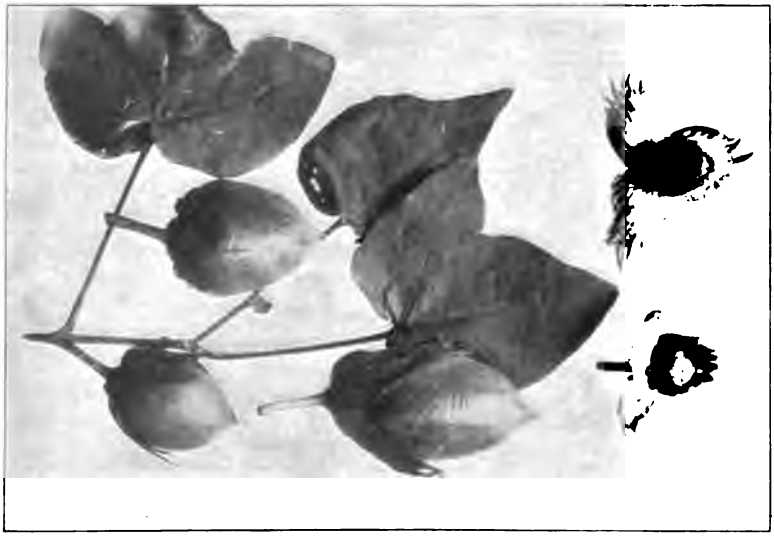


FIG. 1.—RABINAL COTTON WITH BOLLS.

(Reduced.)

FIG. 2.—BOLLS AND SEEDS OF KIDNEY COTTON.

(Reduced.)

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 89.

B. T. GALLOWAY, *Chief of Bureau.*

WILD MEDICINAL PLANTS OF THE UNITED STATES.

BY

ALICE HENKEL,

ASSISTANT, DRUG-PLANT INVESTIGATIONS.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., October 30, 1905.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 89 of the series of this Bureau the accompanying manuscript entitled "Wild Medicinal Plants of the United States." This paper was prepared by Miss Alice Henkel, Assistant in Drug-Plant Investigations, and has been submitted by the Physiologist in Charge with a view to its publication.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

PREFACE.

In connection with the work of Drug-Plant Investigations many inquiries are received from various parts of the country asking for a list of the drug-producing plants of the regions concerned and for information as to the parts of the plants used in medicine, etc. It being impossible to comply with requests of this nature in any satisfactory way, Miss Henkel was asked to compile a list of the drug plants of this country, using as a basis the catalogues of dealers in crude drugs and the standard works on systematic botany. It has seemed from an inspection of these lists and of much current pharmaceutical literature that the recent changes in botanical nomenclature have succeeded one another too rapidly to permit the drug dealer and the pharmacist to keep pace with them. This has resulted in considerable confusion in regard to botanical names, and in some cases in the matter of the common names of drug-producing plants. In such a list as that herewith presented the opportunity for helping to clear up this situation has seemed worth improving. The recent appearance of the new Pharmacopœia, in which the botanical nomenclature has been revised, has seemed to emphasize the desirability of making this attempt, since the names in the case of official plants will be fairly definitely fixed among pharmacists for the next ten years. In the accompanying list the pharmacopœial names are given and a revision of the nomenclature of the unofficial drugs is also presented. Mr. Frederick V. Coville, Botanist, has kindly revised the botanical names used in this publication.

It is hoped that this compilation will tend to unify usage among those who have to do with crude drugs and drug plants.

RODNEY H. TRUE,
Physiologist in Charge

OFFICE OF DRUG-PLANT INVESTIGATIONS,
Washington, D. C., October 12, 1905.

THE PHILADELPHIA
JAN 26 1906
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WILD MEDICINAL PLANTS OF THE UNITED STATES.

In the preparation of this bulletin only such wild medicinal plants as have a commercial value were considered; that is, such as were usually mentioned in the trade lists of drug dealers throughout the country. Plants that were found listed by only one or two firms have been omitted.

Both official and nonofficial drugs are included in this list. A number of drug plants that were official in the United States Pharmacopœia for 1890 have been dropped from the Eighth Decennial Revision (1900), which became official on September 1, 1905, and a few new ones have been added. In this bulletin the drugs that were official in the Pharmacopœia for 1890 are so indicated, while those of the new edition are marked simply "official."

In the following list the information on each species is given under the accepted botanical name. This name and that of the family to which the plant belongs occupy the first line of the description. Botanical synonyms, if any, are mentioned, and these are followed in the next line by the most common names. A few words of information indicating the most important features of habit and stature, as well as the sort of situation in which found, together with the geographical distribution in the United States, are then given in each case. This information is too meager for the identification of the plants concerned in all cases, but it was impossible within the space limits of a publication such as this to include more descriptive matter. The parts of the plants used and the official status of the product close the description. Unless otherwise indicated, the products mentioned are used in the dried state.

Abies balsamea (L.) Mill. **Pine family (Pinaceae).**

Balsam-fir; Canada balsam tree.

Slender, evergreen, native tree, 50 to 60 feet high, occurring in damp woods from Newfoundland to the high mountains of southwestern Virginia, west to Minnesota, and northward.

Parts used.—Balsam, known as Canada turpentine, Canada balsam, or balsam of fir (official); also bark (nonofficial).

Abies canadensis Michx. Same as *Tsuga canadensis.*

Abies nigra Desf. Same as *Picea mariana.*

Abscess-root. See *Polemonium reptans.*

Absinth. See *Artemisia absinthium.*

Absinthium. See *Artemisia absinthium.*

Acacia, false. See *Robinia pseudacacia.*

Acer rubrum L. **Maple family (Aceraceae).**

Red maple; swamp-maple.

Large, native tree, often 120 feet in height, growing in swamps and low grounds from Canada to Florida and Texas.

Part used.—Bark (nonofficial.)

Achillea millefolium L. **Aster family (Asteraceae).**

Yarrow; milfoil; thousandleaf.

Perennial weed, 10 to 20 inches high, common in fields and waste places nearly throughout the United States, especially eastward; naturalized from Europe and Asia.

Part used.—Herb (nonofficial).

Acorus calamus L. **Arum family (Araceae).**

Calamus; sweet-flag.

Native, herbaceous perennial, about 2 feet high, found in wet and muddy places and along streams from Nova Scotia to Minnesota, southward to Florida and Texas.

Part used.—Unpeeled, dried rhizome (official).

Actaea alba (L.) Mill. **Crowfoot family (Ranunculaceae).**

White cohosh; white baneberry; necklace-weed; rattlesnake-herb.

Native, perennial herb, 1 to 2 feet high, found in rich woods from Nova Scotia to Georgia and Missouri, and northward; most common from Indiana and Kentucky to Pennsylvania and New York.

Parts used.—Rhizome and rootlets (nonofficial).

Actaea racemosa L. Same as *Cimicifuga racemosa.*

Actaea rubra (Ait.) Willd. **Crowfoot family (Ranunculaceae).**

Synonym.—*Actaea spicata* var. *rubra* Ait.

Red cohosh; red baneberry; rattlesnake-herb.

Native, perennial herb, 1 to 2 feet high, found in woods from Nova Scotia to the Middle States, west to the Rocky Mountains; most abundant from New England to Ontario.

Parts used.—Rhizome and rootlets (nonofficial).

Actaea spicata var. *rubra* Ait. Same as *Actaea rubra.*

Adam-and-Eve. See *Aplectrum spicatum.*

Adder's-tongue, yellow. See *Erythronium americanum.*

Adiantum pedatum L. **Fern family (Polypodiaceae).**

Maidenhair-fern.

Native fern, 9 to 15 inches high, growing in rich moist soil in woods in Canada and almost all parts of the United States.

Part used.—Herb (nonofficial).

Aesculus glabra Willd. **Buckeye family (Aesculaceae).**

Ohio buckeye; fetid buckeye; smooth buckeye.

Small, native tree, 20 to 40 feet in height, found in woods and on river banks from Pennsylvania south to Alabama, westward to Michigan and the Indian Territory.

Parts used.—Bark and fruit (nonofficial).

Aesculus hippocastanum L. **Buckeye family (Aesculaceae).**

Horse-chestnut.

Large tree, 60 feet or more in height. Escaped from cultivation, southeastern New York and New Jersey. Native of Asia.

Parts used.—Bark and fruit (nonofficial).

Afterbirth-weed. See *Stylosanthes biflora.*

Agrimonia eupatoria (of American authors, not L.). Same as *Agrimonia hirsuta.*

Agrimonia hirsuta (Muhl.) Bicknell. **Rose family (Rosaceae).**

Synonym.—*Agrimonia eupatoria* of most American authors, not L.[a]

Agrimony; tall hairy agrimony.

Perennial herb, 3 to 4 feet high, found in woods and thickets from New Brunswick to Minnesota and Nebraska, south to North Carolina; also in California. Native.

Part used.—Herb (nonofficial).

Agrimony. See *Agrimonia hirsuta.*

Agrimony, tall hairy. See *Agrimonia hirsuta.*

Agropyron repens (L.) Beauv. **Grass family (Poaceae).**

Synonym.—*Triticum repens* Beauv.

Triticum; couch-grass; dog-grass; quack-grass.

A troublesome grass in cultivated land from Maine to Maryland, west to Minnesota and Missouri; sparingly distributed in the South. Introduced from Europe.

Part used.—Rhizome, gathered in spring (official).

Ague-tree. See *Sassafras variifolium.*

Agueweed. See *Eupatorium perfoliatum* and *Gentiana quinquefolia.*

Alder, black. See *Ilex verticillata.*

Alder, common. See *Alnus rugosa.*

Alder, red. See *Alnus rugosa.*

Alder, smooth. See *Alnus rugosa.*

Alder, tag-. See *Alnus rugosa.*

Aletris farinosa L. **Lily family (Liliaceae).**

Star-grass; false (not true) unicorn-root;[b] colic-root.

Native, perennial herb, 2 to 3 feet high; in dry, sandy soil from Maine to Minnesota, south to Florida and Tennessee.

Part used.—Rhizome (nonofficial), gathered after the plant has flowered.

Allspice, Carolina. See *Butneria florida.*

Allspice, Florida. See *Butneria florida.*

Allspice, wild. See *Benzoin benzoin.*

Alnus rugosa (Du Roi) K. Koch. **Birch family (Betulaceae).**

Synonym.—*Alnus serrulata* Willd.

Tag-alder; common alder; red alder; smooth alder.

Native shrub, or sometimes a small tree, occurring in swamps and marshy borders of streams from the New England States west to Minnesota and southward to Florida and Texas.

Part used.—Bark (nonofficial).

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[a] According to Bicknell (Bul. Torr. Bot. Club, 23: 508–525, 1896), the name *Agrimonia eupatoria* L., long used in local floras and text-books for the agrimony of the Eastern States, has been doing duty for a group of related species, of which at least five are now clearly recognized. Furthermore, Doctor Britton (Bul. Torr. Bot. Club, 18: 366, 1891) states that the true *Agrimonia eupatoria* is not known at all as an American plant. The native plant to which the name *Agrimonia eupatoria* has been most frequently applied by American authors is *Agrimonia hirsuta* (Muhl.) Bicknell.

[b] The name "true unicorn-root" has long been applied to *Aletris farinosa*, but as "unicorn-root" was the common name first given to *Chamaelirium luteum* (*Helonias dioica*), this should more properly be called the true unicorn-root and *Aletris farinosa* the false unicorn-root.

Alnus serrulata Willd. Same as *Alnus rugosa.*

Alsine media L. **Pink family (Silenaceae).**

Synonym.—Stellaria media Cyr.

Common chickweed.

Small, annual herb, probably introduced from Europe, and now common in fields and around dwellings throughout the United States.

Part used.—Herb (nonofficial).

Althaea. See *Althaea officinalis.*

Althaea officinalis L. **Mallow family (Malvaceae).**

Althaea; marshmallow; sweatweed; mortification-root.

Perennial herb, 2 to 4 feet high, naturalized from Europe; occurs in salt marshes, coast of Massachusetts and New York, and in Pennsylvania.

Parts used.—Root from plants of second year's growth, deprived of the periderm (official); leaves and flowers (nonofficial) are also used.

Alum-root. See *Geranium maculatum* and *Heuchera americana.*

Ambrosia artemisiaefolia L. **Ragweed family (Ambrosiaceae).**

Roman wormwood; ragweed; hogweed; stammerwort.

Coarse, native weed, annual, 1 to 3 feet high; in waste places, eastern United States, west to British Columbia and Mexico.

Part used.—Herb (nonofficial).

Ampelopsis quinquefolia Michx. Same as *Parthenocissus quinquefolia.*

Amy-root. See *Apocynum cannabinum.*

Anagallis arvensis L. **Primrose family (Primulaceae).**

Red chickweed; red pimpernel; scarlet pimpernel; shepherd's-weatherglass.

Low, spreading, annual herb, naturalized from Europe, and growing along roadsides and in fields almost throughout the United States.

Part used.—Herb (nonofficial).

Anaphalis margaritacea (L.) Benth. & Hook. **Aster family (Asteraceae).**

Synonyms.—Gnaphalium margaritaceum L.; *Antennaria margaritacea* Hook.

Everlasting; pearly everlasting; large-flowered everlasting; cottonweed.

White-hairy or woolly perennial herb, native in dry soil from Newfoundland to Alaska, south to North Carolina and California.

Part used.—Leaves (nonofficial).

Andromeda arborea L. Same as *Oxydendrum arboreum.*

Anemone patens var. *nuttalliana* A. Gray. Same as *Pulsatilla hirsutissima.*

Angelica, American. See *Angelica atropurpurea.*

Angelica atropurpurea L. **Parsley family (Apiaceae).**

Synonym.—Archangelica atropurpurea Hoffm.

Purple-stemmed angelica; American angelica; masterwort.

Tall, stout, perennial herb, 4 to 6 feet high; native in swamps and damp places from Labrador to Delaware and west to Minnesota.

Parts used.—Root and seeds (nonofficial).

Angelica, purple-stemmed. See *Angelica atropurpurea.*

Anise-root. See *Washingtonia longistylis.*

Antennaria margaritacea Hook. Same as *Anaphalis margaritacea.*

Anthemis cotula L. **Aster family (Asteraceae).**

Synonym.—Maruta cotula DC.

Mayweed; dog-fennel; fetid camomile (or chamomile).

Strong-scented, annual herb, naturalized from Europe; occurs in dry soil, fields, waste places, and along roadsides almost throughout North America, with the exception of the extreme North.

Part used.—Herb (nonofficial).

Aplectrum hyemale Nutt. Same as *Aplectrum spicatum*.

Aplectrum spicatum (Walt.) B. S. P. **Orchid family (Orchidaceae).**

Synonym.—Aplectrum hyemale Nutt.

Adam-and-Eve; putty-root.

Native herb, perennial, 1 to 2 feet high; in rich woods and swamps from Canada to Georgia and California.

Part used.—Root (nonofficial).

Apocynum. See *Apocynum cannabinum*.

Apocynum androsaemifolium L. **Dogbane family (Apocynaceae).**

Bitterroot; spreading dogbane; honeybloom.

Perennial herb, 1 to 4 feet high, native in fields and thickets from Canada south to Georgia and Arizona. The most common species in Canada and the Northeastern States.

Part used.—Root (nonofficial).

Apocynum cannabinum L. **Dogbane family (Apocynaceae).**

Apocynum; Canadian hemp; black Indian hemp; amy-root.

Perennial herb, 2 to 3 feet high, native in moist ground and borders of fields throughout the United States.

Part used.—Rhizome of this or of closely allied species of Apocynum (official).

Apple, custard-. See *Asimina triloba*.

Apple, May-. See *Podophyllum peltatum*.

Apple, thorn-. See *Datura stramonium*.

Apple-of-Peru. See *Datura stramonium*.

Aquilegia canadensis L. See under *Aquilegia vulgaris*.

Aquilegia vulgaris L. **Crowfoot family (Ranunculaceae).**

European columbine; garden-columbine.

Perennial herb, with showy flowers. Naturalized from Europe, and well known in cultivation; escaped from gardens into woods and fields; frequent in the Eastern and Middle States. The wild columbine (*Aquilegia canadensis* L.), occurring in rocky woods throughout Canada and the eastern United States, is said to possess properties similar to those of the European columbine.

Part used.—Herb (nonofficial).

Aralia hispida Vent. **Ginseng family (Araliaceae).**

Dwarf elder; wild elder; bristly sarsaparilla.

Erect, leafy perennial, 1 to 3 feet high, native in sandy woods and fields from Labrador south to North Carolina, west to Minnesota and Indiana.

Part used.—Root (nonofficial).

Aralia nudicaulis L. **Ginseng family (Araliaceae).**

American sarsaparilla; wild sarsaparilla; false sarsaparilla; Virginian sarsaparilla; small spikenard.

Herbaceous perennial, native, growing in moist woods from Newfoundland west to Manitoba and south to North Carolina and Missouri.

Part used.—Root (nonofficial).

Aralia racemosa L. **Ginseng family (Araliaceae).**

Indian-root; spikenard; American spikenard; spignet.

Herbaceous perennial, native, 3 to 6 feet high, growing in rich woods and rocky places from Canada to Georgia, west to Minnesota and Missouri.

Part used.—Root (nonofficial).

Arbor-vitae. See *Thuja occidentalis*.

Arbutus, trailing. See *Epigaea repens*.

Archangelica atropurpurea Hoffm. Same as *Angelica atropurpurea*.

Arctium lappa L. **Aster family (Asteraceae).**

Synonym.—*Lappa major* Gaertn.

Lappa; burdock; cockle-button; beggars'-buttons; bardane.

Coarse, biennial weed, 4 to 9 feet high, introduced from the Old World, and occurring along roadsides and in fields and waste places in the Eastern and Central States.

Parts used.—Root of this or of other species of Arctium collected from plants of first year's growth (official). The fresh leaves and the seeds are also used (nonofficial).

Arctostaphylos glauca Lindl. **Heath family (Ericaceae).**

Manzanita.

A shrub-like tree, 9 to 25 feet high, growing in California, in dry, rocky districts on the western slopes of the Sierras.

Part used.—Leaves (nonofficial).

Arctostaphylos uva-ursi (L.) Spreng. **Heath family (Ericaceae).**

Uva-ursi; bearberry; upland-cranberry.

Low, evergreen perennial, with trailing stems, native in rocky or dry, sandy soils from the Middle Atlantic States north to Labrador, westward to California and Alaska.

Part used.—Leaves (official).

Arisaema triphyllum (L.) Torr. **Arum family (Araceae).**

Synonym.—*Arum triphyllum* L.

Indian turnip; wild turnip; wake-robin; Jack-in-the-pulpit.

Native, perennial herb, 10 inches to 3 feet high, found in moist woods from Canada to Florida, west to Kansas and Minnesota.

Part used.—Partially dried corm (nonofficial).

Aristolochia reticulata Nutt. **Birthwort family (Aristolochiaceae).**

Serpentaria; Texas serpentaria; Texas snakeroot; Red River snakeroot.

Perennial herb, about 1½ feet in height, native in the Southwestern States, occurring on river banks from Arkansas to Louisiana.

Parts used.—Rhizome and roots (official).

Aristolochia serpentaria L. **Birthwort family (Aristolochiaceae).**

Serpentaria; Virginia serpentaria; Virginia snakeroot.

Native, perennial herb, 10 inches to 3 feet high, found in rich woods from Connecticut to Michigan and southward.

Parts used.—Rhizome and roots (official).

Arrowwood. See *Viburnum dentatum.*

Arrowwood, Indian. See *Euonymus atropurpureus.*

Artemisia abrotanum L. **Aster family (Asteraceae).**

Southernwood.

Shrubby, perennial herb, about 2 to 4 feet in height, occurring in waste places from Massachusetts to Nebraska. Adventive from Europe.

Part used.—Herb (nonofficial).

Artemisia absinthium L. **Aster family (Asteraceae).**

Absinthium; wormwood; absinth.

Shrubby, perennial herb, 2 to 3 feet high, naturalized from Europe, and occurring in waste places and along roadsides from Newfoundland to New York and westward.

Parts used.—Leaves and tops (official in U. S. P. 1890).

Artemisia vulgaris L. **Aster family (Asteraceae).**

Common mugwort.

Perennial herb, 1 to 3½ feet high, naturalized from Europe; found in waste places, Nova Scotia to the Middle States and westward to Michigan.

Part used.—Herb (nonofficial).

Arum triphyllum L. Same as *Arisaema triphyllum.*

Asarum canadense L. **Birthwort family (Aristolochiaceae).**

Canada snakeroot; wild ginger; Indian ginger.

Perennial herb, about 1 foot in height, native in rich woods from Canada to North Carolina and Kansas.

Parts used.—Rhizome and rootlets (nonofficial).

Asclepias. See *Asclepias tuberosa.*

Asclepias cornuti Dec. Same as *Asclepias syriaca.*

Asclepias incarnata L. **Milkweed family (Asclepiadaceae).**

White Indian hemp; swamp-milkweed; swamp-silkweed; rose-colored silkweed.

Perennial herb, 2 to 4 feet high, native in swamps from Canada to Tennessee and Kansas.

Part used.—Root (nonofficial).

Asclepias syriaca L. **Milkweed family (Asclepiadaceae).**

Synonym.—*Asclepias cornuti* Dec.

Common milkweed; silkweed.

Perennial herb, 3 to 5 feet high, native in fields and waste places from Canada to North Carolina and Kansas.

Part used.—Root (nonofficial).

Asclepias tuberosa L. **Milkweed family (Asclepiadaceae).**

Asclepias; pleurisy-root; butterfly-weed; Canada-root; whiteroot.

Native, perennial herb, 1 to 2 feet high, growing in dry fields from Canada to Florida and Arizona; most abundant southward.

Part used.—Root (official in U. S. P. 1890).

Ash, American mountain-. See *Sorbus americana.*

Ash, black. See *Fraxinus nigra.*

Ash, cane-. See *Fraxinus americana.*

Ash, hoop-. See *Fraxinus nigra.*

Ash, prickly. See *Fagara clava-herculis* and *Xanthoxylum americanum.*

Ash, wafer-. See *Ptelea trifoliata.*

Ash, white. See *Fraxinus americana.*

Asimina triloba (L.) Dunal. **Custard-apple family (Anonaceae).**

North American pawpaw; custard-apple.

Small, native tree, growing in rich soil along the banks of streams from New York to Michigan and southward. Most common in the Ohio Valley.

Part used.—Seed (nonofficial).

Aspen, American. See *Populus tremuloides.*

Aspen, quaking. See *Populus tremuloides.*

Aspidium. See *Dryopteris filix-mas* and *D. marginalis.*

Aspidium filix-mas Sw. Same as *Dryopteris filix-mas.*

Aspidium marginale Sw. Same as *Dryopteris marginalis.*

Asplenium filix-foemina (L.) Bernh. Same as *Athyrium filix-foemina.*

Aster puniceus L. **Aster family (Asteraceae).**

Red-stalked aster; cocash; meadow-scabish.

Perennial herb, with stout, reddish stem, 3 to 8 feet high, native; in swamps and on banks of streams, Nova Scotia to Minnesota, south to North Carolina, Ohio, and Michigan.

Part used.—Root (nonofficial).

Aster, red-stalked. See *Aster puniceus.*

Asthma-weed, Queensland. See *Euphorbia pilulifera.*

Athyrium filix-foemina (L.) Roth. **Fern family (Polypodiaceae).**

Synonym.—*Asplenium filix-foemina* (L.) Bernh.

Backache-brake; female-fern; lady-fern.

Native fern, with leaves 1 to 3 feet long; in woods and thickets, Canada to Alaska, southward to Florida and Arizona.

Part used.—Rhizome (nonofficial).

Avens, purple. See *Geum rivale.*

Avens, water-. See *Geum rivale.*

Backache-brake. See *Athyrium filix-foemina.*

Backache-root. See *Lacinaria spicata.*

Balm. See *Melissa officinalis.*

Balm, bee-. See *Monarda didyma.*

Balm, field-. See *Glecoma hederacea.*

Balm, garden-. See *Melissa officinalis.*

Balm, horse-. See *Collinsonia canadensis.*

Balm, lemon-. See *Melissa officinalis.*

Balm, mountain-. See *Eriodictyon californicum.*

Balm, scarlet. See *Monarda didyma.*

Balm, sweet. See *Melissa officinalis.*

Balm-of-Gilead. See *Populus candicans.*

Balmony. See *Chelone glabra.*

Balsam, sweet. See *Gnaphalium obtusifolium.*

Balsam tree, Canada. See *Abies balsamea.*

Balsam, white. See *Gnaphalium obtusifolium.*

Balsam-fir. See *Abies balsamea.*

Bamboo-brier. See *Smilax pseudo-china.*

Baneberry, red. See *Actaea rubra.*

Baneberry, white. See *Actaea alba.*

Baptisia tinctoria (L.) R. Br. **Pea family (Fabaceae).**

Wild indigo; yellow indigo; American indigo; indigo-weed; horsefly-weed.

Native, perennial herb, 2 to 3 feet high, growing in dry, poor soil from Maine to Minnesota, south to Florida and Louisiana.

Parts used.—Root and leaves (nonofficial).

Barberry, holly-leaved. See *Berberis aquifolium.*

Bardane. See *Arctium lappa.*

Basswood. See *Tilia americana.*

Bay, rose-. See *Rhododendron maximum.*

Bay, sweet. See *Magnolia virginiana.*

Bay, white. See *Magnolia virginiana.*

Bayberry. See *Myrica cerifera.*

Bean, bog-. See *Menyanthes trifoliata.*

Bean, buck-. See *Menyanthes trifoliata.*

Bean, hog's-. See *Hyoscyamus niger.*

Bearberry. See *Arctostaphylos uva-ursi.*

Bearberry-tree. See *Rhamnus purshiana.*

Bear's-foot, yellow. See *Polymnia uvedalia.*

Bear's-weed. See *Eriodictyon californicum.*

Beaver-poison. See *Cicuta maculata.*

Beaverroot. See *Nymphaea advena.*

Beaver-tree. See *Magnolia virginiana.*

Bedstraw. See *Galium aparine.*

Bee-balm. See *Monarda didyma.*

Beech, American. See *Fagus americana.*

Beechdrops. See *Leptamnium virginianum.*

Beechnut-tree. See *Fagus americana.*

Bee-plant. See *Scrophularia marilandica.*

Beggars'-buttons. See *Arctium lappa.*

Bellwort, perfoliate. See *Uvularia perfoliata.*

Benjamin-bush. See *Benzoin benzoin.*

Bennet. See *Pimpinella saxifraga.*

Benzoin benzoin (L.) Coulter. **Laurel family (Lauraceae).**

Synonyms.—*Laurus benzoin* L.; *Lindera benzoin* Meissn.; *Benzoin odoriferum* Nees.

Spicebush; feverbush; Benjamin-bush; wild allspice; spicewood.

Indigenous shrub, 5 to 12 feet high; in damp, shady woods, and along streams, Massachusetts to Michigan, south to North Carolina and Kansas.

Parts used.—Bark and berries (nonofficial).

Benzoin odoriferum Nees. Same as *Benzoin benzoin.*

Berberis. See *Berberis aquifolium.*

Berberis aquifolium Pursh. **Barberry family (Berberidaceae).**

Berberis; Oregon grape; holly-leaved barberry; Rocky Mountain grape.

A shrub, native in woods from Colorado to the Pacific Ocean; especially abundant in Oregon and northern California.

Parts used.—Rhizome and roots of this and of other species of Berberis (official).

Bergamot, wild. See *Monarda fistulosa.*

Bethroot, ill-scented. See *Trillium erectum.*

Betony, Paul's-. See *Veronica officinalis.*

Betula lenta L. **Birch family (Betulaceae).**

Sweet birch; black birch; cherry birch.

Large, indigenous forest tree; Newfoundland to Ontario, south to Florida and Tennessee.

Part used.—Bark (nonofficial). Oil of betula, obtained by maceration and distillation from the bark, is official.

Bikukulla canadensis (Goldie) Millsp. **Poppy family (Papaveraceae).**

Synonyms.—*Corydalis formosa* Pursh; *Corydalis canadensis* Goldie; *Dicentra canadensis* Walp.

Turkey-corn; squirrel-corn; turkey-pea; staggerweed.

Native, perennial plant, 6 to 12 inches high; in rich woods from Nova Scotia south along the mountains to Kentucky, and westward to Missouri and Minnesota.

Part used.—Tubers (nonofficial).

Birch, black. See *Betula lenta.*

Birch, cherry. See *Betula lenta.*

Birch, sweet. See *Betula lenta.*

Bird's-foot violet. See *Viola pedata.*

Birthroot. See *Trillium erectum.*

Bitterbloom. See *Sabbatia angularis.*

Bitter-buttons. See *Tanacetum vulgare.*

Bitterroot. See *Apocynum androsaemifolium.*

Bittersweet. See *Solanum dulcamara.*

Bittersweet, false. See *Celastrus scandens.*

Bitterweed. See *Erigeron canadensis.*

Blackberry, high-bush. See *Rubus nigrobaccus.*

Blackberry, knee-high. See *Rubus cuneifolius.*

Blackberry, low running. See *Rubus procumbens.*

Blackberry, low-bush. See *Rubus trivialis.*

Blackberry, sand-. See *Rubus cuneifolius.*

Blackcap. See *Rubus occidentalis.*

Blackroot. See *Veronica virginica.*

Blackroot, Indian. See *Pterocaulon undulatum.*

Blackwort. See *Symphytum officinale.*

Bladderpod. See *Lobelia inflata.*

Blazingstar. See *Chamaelirium luteum.*

Blazingstar, blue. See *Lacinaria scariosa.*

Blazingstar, scaly. See *Lacinaria squarrosa.*

Bloodroot. See *Sanguinaria canadensis.*

Bloodwort. See *Hieracium venosum.*

Bloodwort, striped. See *Hieracium venosum.*

Blowball. See *Taraxacum officinale.*

Blue-curls. See *Prunella vulgaris.*

Bog-bean. See *Menyanthes trifoliata.*

Bog-myrtle. See *Myrica gale.*

Boneset. See *Eupatorium perfoliatum.*

Boneset, deerwort-. See *Eupatorium ageratoides.*

Boneset, purple. See *Eupatorium purpureum.*

Bouncing-Bet. See *Saponaria officinalis.*

Bowman's-root. See *Porteranthus trifoliatus* and *Veronica virginica.*

Boxwood. See *Cornus florida.*

Brake, backache-. See *Athyrium filix-foemina.*

Brake, buckhorn-. See *Osmunda regalis.*

Brake, rock-. See *Polypodium vulgare.*

Brassica nigra (L.) Koch. **Mustard family (Brassicaceae).**

Synonym.—Sinapis nigra L.

Sinapis nigra; black mustard; brown mustard; red mustard.

Annual herb, introduced from Europe; found in fields and waste places almost throughout the United States.

Part used.—Seed (official); the volatile oil obtained from black mustard seed is also official.

Brauneria angustifolia (DC.) Heller. **Aster family (Asteraceae).**

Synonym.—Echinacea angustifolia DC.

Echinacea; pale-purple coneflower; Sampson-root; niggerhead (in Kansas).

Native, perennial, herbaceous plant, 2 to 3 feet high, occurring in rich prairie soil or sandy soil from Alabama to Texas and northwestward; most abundant in Kansas and Nebraska.

Part used.—Root (nonofficial).

Broom. See *Cytisus scoparius.*

Broom, green. See *Cytisus scoparius.*

Broom, Scotch. See *Cytisus scoparius.*

Brownwort. See *Prunella vulgaris.*

Bruisewort. See *Symphytum officinale.*

Buck-bean. See *Menyanthes trifoliata.*

Buckeye, fetid. See *Aesculus glabra.*

Buckeye, Ohio. See *Aesculus glabra.*

Buckeye, smooth. See *Aesculus glabra.*

Buckhorn-brake. See *Osmunda regalis.*

Buckthorn. See *Rhamnus cathartica.*

Bugle, sweet. See *Lycopus virginicus.*

Bugle, water-. See *Lycopus virginicus.*

Bugleweed. See *Lycopus virginicus.*

Bullbrier. See *Smilax pseudo-china.*

Bull-nettle. See *Solanum carolinense.*

Bulrush. See *Typha latifolia.*

Burdock. See *Arctium lappa.*

Burnet-saxifrage. See *Pimpinella saxifraga.*

Burningbush. See *Euonymus atropurpurea.*

Bursa bursa-pastoris (L.) Britton. **Mustard family (Brassicaceae).**

Synonym.—Capsella bursa-pastoris Medic.

Shepherd's-purse; cocowort; toywort.

Annual plant, about 1 foot in height, found in fields and waste places; widely distributed. Introduced from Europe.

Part used.—Herb (nonofficial).

Burseed, spiny. See *Xanthium spinosum.*

Burweed, thorny. See *Xanthium spinosum.*

Butneria florida (L.) Kearney. **Strawberry-shrub family (Calycanthaceae).**

Synonym.—Calycanthus floridus L.

Hairy strawberry-shrub; sweet-scented shrub; Carolina allspice; Florida allspice.

Native shrub, 4 to 8 feet high; in rich soil, Virginia to Mississippi.

Part used.—Bark (nonofficial).

Butterfly-weed. See *Asclepias tuberosa.*

Butternut. See *Juglans cinerea.*

Buttonbush. See *Cephalanthus occidentalis.*

Button-snakeroot. See *Eryngium yuccifolium.*

Button-snakeroot, dense. See *Lacinaria spicata.*

Button-snakeroot, large. See *Lacinaria scariosa.*

Button-tree. See *Cephalanthus occidentalis.*

Buttonwood-shrub. See *Cephalanthus occidentalis.*

Cabbage, skunk-. See *Spathyema foetida.*

Cabbage, swamp-. See *Spathyema foetida.*

Calamus. See *Acorus calamus.*

Calfkill. See *Kalmia angustifolia.*

Calico-bush. See *Kalmia latifolia.*

Calycanthus floridus L. Same as *Butneria florida.*

Camomile, fetid. See *Anthemis cotula.*

Canada balsam tree. See *Abies balsamea.*

Canada-root. See *Asclepias tuberosa.*

Cancerroot. See *Leptamnium virginianum.*

Candleberry. See *Myrica cerifera.*

Cane-ash. See *Fraxinus americana.*

Cankerroot. See *Coptis trifolia* and *Limonium carolinianum.*

Canker-weed. See *Nabalus serpentarius.*

Canker-weed, white. See *Nabalus albus.*

Cankerwort. See *Taraxacum officinale.*

Canoewood. See *Liriodendron tulipifera.*

Capsella bursa-pastoris Medic. Same as *Bursa bursa-pastoris.*

Cardinal, red. See *Lobelia cardinalis.*

Cardinal-flower. See *Lobelia cardinalis.*

Cardinal-flower, blue. See *Lobelia siphilitica.*

Carduus arvensis (L.) Robs. **Aster family (Asteraceae).**

Synonym.—*Cirsium arvense* Scop.

Canada thistle; creeping thistle; cursed thistle.

Perennial herb, 1 to 3 feet high; growing in cultivated fields, pastures, and waste places from Newfoundland to Virginia, west to Minnesota and Nebraska. A bad weed, introduced from Europe.

Part used.—Root (nonofficial).

Carduus benedictus Auct. Same as *Cnicus benedictus.*

Carpenter's-square. See *Scrophularia marilandica.*

Carrion-flower. See *Smilax herbacea.*

Carrot, wild. See *Daucus carota.*

Carya alba Nutt. Same as *Hicoria ovata.*

Cascara sagrada. See *Rhamnus purshiana.*

Cassia marilandica L. **Senna family (Caesalpiniaceae).**

American senna; wild senna; locust-plant.

Native, perennial herb; in swamps and wet soil, New England to Florida, west to Louisiana and Nebraska.

Part used.—Leaves (nonofficial).

Castalia odorata (Dryand.) Woodv. & Wood.

Water-lily family (Nymphaeaceae).

Synonym.—*Nymphaea odorata* Dryand.

White pond-lily; water-lily; sweet-scented water-lily.

Indigenous, aquatic herb; perennial; in ponds, marshes, and sluggish streams, from Canada to Florida and Louisiana.

Part used.—Rhizome (nonofficial).

Castanea. See *Castanea dentata.*

Castanea dentata (Marsh.) Borkh. **Beech family (Fagaceae).**

Castanea; chestnut; American chestnut.

A large, spreading tree, occurring in rich woods from Maine to Michigan, south to Tennessee. Especially abundant in the Allegheny region. Native.

Part used.—Leaves (official in U. S. P. 1890).

Catchweed. See *Galium aparine.*

Catfoot. See *Glecoma hederacea.*

Catgut. See *Cracca virginiana.*

Catmint. See *Nepeta cataria.*

Catnip. See *Nepeta cataria.*

Cattail, broad-leaved. See *Typha latifolia.*

Cattail-flag. See *Typha latifolia.*

Caulophyllum. See *Caulophyllum thalictroides.*

Caulophyllum thalictroides (L.) Michx. **Barberry family (Berberidaceae).**

Caulophyllum; blue cohosh; squawroot; papoose-root.

Native, perennial herb, 1 to 3 feet high; found in rich, shady woods from New Brunswick to South Carolina, westward to Nebraska; abundant throughout the Allegheny Mountain region.

Parts used.—Rhizome and roots (official in U. S. P. 1890).

Ceanothus americanus L. **Buckthorn family (Rhamnaceae).**

Jersey tea; New Jersey tea; redroot.

A native shrub, growing in dry, open woods from Canada to Florida and Texas.

Parts used.—Root, root-bark, and leaves (nonofficial).

Cedar, red. See *Juniperus virginiana.*

Cedar, shrubby red. See *Juniperus sabina.*

Cedar, white. See *Thuja occidentalis.*

Cedar, yellow. See *Thuja occidentalis.*

Celandine. See *Chelidonium majus.*

Celandine, garden-. See *Chelidonium majus.*

Celandine, great. See *Chelidonium majus.*

Celandine, wild. See *Impatiens aurea.*

Celastrus scandens L. **Staff-tree family (Celastraceae).**

False bittersweet; staff-tree; waxwork; fevertwig.

An indigenous, twining, woody vine; in rich, damp soil, woods, and thickets, Ontario to Manitoba, south to North Carolina and New Mexico.

Part used.—Bark of plant and of root (nonofficial).

Centaurea benedicta L. Same as *Cnicus benedictus.*

Centaury, American. See *Sabbatia angularis.*

Centaury, ground-. See *Polygala nuttallii.*

Cephalanthus occidentalis L. **Madder family (Rubiaceae).**

Buttonbush; button-tree; buttonwood-shrub; globeflower.

Indigenous shrub, 6 to 12 feet high; in swamps and damp places, Canada to Florida and California.

Part used.—Bark (nonofficial).

Cercis canadensis L. **Senna family (Caesalpiniaceae).**

Judas-tree; redbud.

Small, native tree, growing in rich soil from New Jersey to Minnesota, south to Florida and Texas.

Part used.—Bark of root (nonofficial).

Chamaelirium luteum (L.) A. Gray. **Bunchflower family (Melanthiaceae).**

Synonym.—*Helonias dioica* Pursh.

True (not false) unicorn-root;[a] blazingstar; starwort; drooping starwort.

Slender, perennial herb, about 2 feet high; native in moist meadows and thickets from Massachusetts to Michigan, south to Florida and Arkansas.

Part used.—Rhizome (nonofficial).

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[a] The name "unicorn-root" was first applied to *Chamaelirium luteum*, and the designation "true unicorn-root" would seem to belong more properly to that species than to *Aletris farinosa*, to which the name unicorn-root was given later, and which may thus be called "false unicorn-root."

Chamaenerion angustifolium (L.) Scop. **Evening-primrose family (Onagraceae).**

Synonym.—*Epilobium angustifolium* L.

Great willow-herb; wickup.

Native, perennial herb, 2 to 8 feet high, found in dry soil from Canada to Alaska, south to North Carolina, Arizona, and California. Very common from Pennsylvania northward.

Parts used.—Leaves and root (nonofficial).

Chamomile, fetid. See *Anthemis cotula.*

Champion-oak. See *Quercus rubra.*

Checkerberry. See *Gaultheria procumbens* and *Mitchella repens.*

Cheeseflower. See *Malva sylvestris.*

Cheeses. See *Malva rotundifolia.*

Chelidonium. See *Chelidonium majus.*

Chelidonium majus L. **Poppy family (Papaveraceae).**

Chelidonium; celandine; garden-celandine; great celandine; tetterwort.

Perennial herb, 1 to 2 feet high, growing along fences, roadsides, and in waste places; common in the East. Naturalized from Europe.

Part used.—Entire plant (official in U. S. P. 1890).

Chelone glabra L. **Figwort family (Scrophulariaceae).**

Balmony; turtle-head; shellflower; snakehead; salt-rheum weed.

Native, perennial, herbaceous plant, 2 to 3 feet high; in swamps and along streams, Newfoundland to Manitoba, south to Florida and Kansas.

Part used.—Herb, and especially the leaves (nonofficial).

Chenopodium. See *Chenopodium ambrosioides* and *C. anthelminticum.*

Chenopodium ambrosioides L. **Goosefoot family (Chenopodiaceae).**

Chenopodium; Mexican tea; American wormseed; Jerusalem tea; Spanish tea.

Strong-scented herb, 2 to 3 feet high, annual; naturalized from tropical America, and occurring in waste places, meadows, and pastures from New England to Florida, west to California.

Part used.—Fruit (official in U. S. P. 1890).

Chenopodium anthelminticum L. **Goosefoot family (Chenopodiaceae).**

Chenopodium; wormseed; Jerusalem oak.

Annual, sometimes perennial, herb, usually taller than *C. ambrosioides*, naturalized from Europe, and found in waste places from southern New York to Wisconsin, south to Florida and Mexico.

Parts used.—Fruit (official in U. S. P. 1890). The oil of chenopodium, distilled from this plant, is official.

Chenopodium botrys L. **Goosefoot family (Chenopodiaceae).**

Jerusalem oak.

Annual herb, about 2 feet high, introduced from Europe; found in waste places from Nova Scotia to New York and Kentucky, westward to Oregon.

Parts used.—Herb and seeds (nonofficial).

Cherry birch. See *Betula lenta.*

Cherry, rum-. See *Prunus serotina.*

Cherry, wild. See *Prunus serotina.*

Chervil, sweet. See *Washingtonia longistylis.*

Chestnut. See *Castanea dentata.*

Chestnut, American. See *Castanea dentata.*

Chestnut, horse-. See *Aesculus hippocastanum.*

Chickentoe. See *Corallorhiza odontorhiza.*

Chickweed, common. See *Alsine media.*

Chickweed, red. See *Anagallis arvensis.*

Chicory. See *Cichorium intybus.*

Chimaphila. See *Chimaphila umbellata.*

Chimaphila umbellata (L.) Nutt. **Wintergreen family (Pyrolaceae).**

Chimaphila; pipsissewa; prince's-pine; bitter wintergreen; rheumatism-weed.

Small, perennial herb, native in dry, shady woods, especially in pine forests, from Nova Scotia to Georgia, west to California.

Part used.—Leaves (official).

China-root, American. See *Smilax pseudo-china.*

China-root, false. See *Smilax pseudo-china.*

Chionanthus virginica L. **Olive family (Oleaceae).**

Fringe-tree; old-man's-beard.

A shrub or small tree, native in moist thickets from Delaware to Florida and Texas.

Part used.—Bark of root (nonofficial).

Chittem-bark. See *Rhamnus purshiana.*

Chrysanthemum leucanthemum L. **Aster family (Asteraceae).**

Synonym.—Leucanthemum vulgare Lam.

Oxeye daisy; white daisy.

Perennial herb, 1 to 3 feet high, naturalized from Europe; occurring in pastures, meadows, and waste places in nearly every section of the country, but less abundantly in the South and rarely in the West.

Part used.—Herb (nonofficial).

Chrysanthemum parthenium (L.) Pers. **Aster family (Asteraceae).**

Synonym.—Pyrethrum parthenium Smith.

Common feverfew; featherfew; febrifuge-plant.

Perennial herb, naturalized from Europe. Mostly escaped from cultivation; in waste places, New Brunswick to New Jersey, and locally in the interior.

Part used.—Herb (nonofficial).

Cichorium intybus L. **Chicory family (Cichoriaceae).**

Chicory; succory.

Perennial herb, 1 to 3 feet high, growing in fields, waste places, and along roadsides from Nova Scotia to North Carolina, west to Nebraska. Abundant eastward. Naturalized from Europe.

Part used.—Root (nonofficial).

Cicuta maculata L. **Parsley family (Apiaceae).**

Water-hemlock; musquash-root; beaver-poison.

Native perennial, 3 to 6 feet high, stout, erect; poisonous. Found in swamps and low grounds from Canada south to Florida and New Mexico.

Part used.—Leaves (nonofficial).

Cimicifuga. See *Cimicifuga racemosa.*

Cimicifuga racemosa (L.) Nutt. **Crowfoot family (Ranunculaceae).**

Synonym.—Actaea racemosa L.

Cimicifuga; black snakeroot; black cohosh; squawroot; rattle-root.

Native, perennial herb, 3 to 8 feet high; in rich soil in shady woods, Maine to Georgia, west to Wisconsin and Missouri. Most abundant in the Ohio Valley.

Parts used.—Rhizome and roots (official).

Cinquefoil. See *Potentilla canadensis.*

Cirsium arvense Scop. Same as *Carduus arvensis.*

Cleavers. See *Galium aparine.*

Cleaverwort. See *Galium aparine.*

Clematis. See *Clematis virginiana.*

Clematis virginiana L. **Crowfoot family (Ranunculaceae).**

Virgin's-bower; clematis.

Shrubby, perennial vine; native; found along river banks in hedges and thickets from Canada to Georgia and Kansas.

Parts used.—Leaves and flowers (nonofficial).

Clotbur, spiny. See *Xanthium spinosum.*

Clotweed, thorny. See *Xanthium spinosum.*

Clover, bitter. See *Sabbatia angularis.*

Clover, meadow-. See *Trifolium pratense.*

Clover, purple. See *Trifolium pratense.*

Clover, red. See *Trifolium pratense.*

Clover, yellow sweet. See *Melilotus officinalis.*

Club-moss. See *Lycopodium clavatum.*

Cnicus benedictus L. **Aster family (Asteraceae).**

Synonyms.—*Carduus benedictus* Auct.; *Centaurea benedicta* L.

Blessed thistle; holy thistle; bitter thistle; spotted thistle; St. Benedict's-thistle.

Annual plant, 1 to 2 feet high; in waste places, Southern States, and in California and Utah; introduced from Europe.

Part used.—Herb (nonofficial).

Cocash. See *Aster puniceus.*

Cocash-weed. See *Senecio aureus.*

Cockle-but'on. See *Arctium lappa.*

Cocowort. See *Bursa bursa-pastoris.*

Cohosh, black. See *Cimicifuga racemosa.*

Cohosh, blue. See *Caulophyllum thalictroides.*

Cohosh, red. See *Actaea rubra.*

Cohosh, white. See *Actaea alba.*

Colic-root. See *Aletris farinosa, Dioscorea villosa, Lacinaria spicata,* and *L. squarrosa.*

Collinsonia canadensis L. **Mint family (Menthaceae).**

Stoneroot; richweed; knobroot; horse-balm.

Native, perennial herb, about 2 feet high, occurring in rich, moist woods from Maine to Wisconsin, south to Florida and Kansas.

Parts used.—Root and leaves (nonofficial).

Colt's-foot. See *Tussilago farfara.*

Colt's-tail. See *Erigeron canadensis.*

Columbine, European. See *Aquilegia vulgaris.*

Columbine, garden-. See *Aquilegia vulgaris.*

Columbine, wild. See under *Aquilegia vulgaris.*

Columbo, American. See *Frasera carolinensis.*

Comfrey. See *Symphytum officinale.*

Compass-plant. See *Silphium laciniatum.*

Comptonia asplenifolia Gaertn. Same as *Comptonia peregrina.*

Comptonia peregrina (L.) Coulter. **Bayberry family (Myricaceae).**

Synonyms.—*Comptonia asplenifolia* Gaertn.; *Myrica asplenifolia* L.

Sweet fern; spleenwortbush; meadow-fern.

Shrubby plant, about 2½ feet high, native; in thin sandy or stony woods and on hillsides, Canada to North Carolina, Indiana, and Michigan.

Parts used.—Leaves and tops (nonofficial).

Coneflower, pale-purple. See *Brauneria angustifolia.*

Coneflower, tall. See *Rudbeckia laciniata.*

Congo-root. See *Psoralea pedunculata.*

Conium. See *Conium maculatum.*

Conium maculatum L. **Parsley family (Apiaceae).**

Conium; poison-hemlock; spotted parsley; spotted cowbane.

Biennial herb, 2 to 6 feet high, naturalized from Europe; common in waste places, especially in the Eastern and Middle States. Poisonous.

Parts used.—Full-grown, but unripe, fruit, carefully dried and preserved (official); leaves (nonofficial).

Consumptive's-weed. See *Eriodictyon californicum.*

Convallaria. See *Convallaria majalis.*

Convallaria biflora Walt. Same as *Polygonatum biflorum.*

Convallaria majalis L. **Lily-of-the-valley family (Convallariaceae).**

Convallaria; lily-of-the-valley.

A low, perennial herb; indigenous; on the higher mountains from Virginia to the Carolinas.

Parts used.—Rhizome and roots (official); herb and flowers (nonofficial).

Convallaria racemosa L. Same as *Vagnera racemosa.*

Convolvulus panduratus L. Same as *Ipomoea pandurata.*

Coolwort. See *Tiarella cordifolia.*

Coptis trifolia (L.) Salisb. **Crowfoot family (Ranunculaceae).**

Goldthread; cankerroot; mouthroot; yellowroot.

Low, native, perennial herb, growing in damp mossy woods and bogs from Canada and Alaska south to Maryland and Minnesota; most common in the New England States, northern New York and Michigan, and in Canada.

Parts used.—Rhizome and rootlets (nonofficial).

Corallorhiza odontorhiza (Willd.) Nutt. **Orchid family (Orchidaceae).**

Crawley-root; coralroot; dragon's-claw; chickentoe.

Leafless plant, 6 to 15 inches high, found in rich woods from Maine to Florida, west to Michigan and Missouri. Native.

Part used.—Rhizome (nonofficial).

Coralroot. See *Corallorhiza odontorhiza.*

Corn, squirrel-. See *Bikukulla canadensis.*

Corn, turkey-. See *Bikukulla canadensis.*

Cornel, silky. See *Cornus amomum.*

Corn-snakeroot. See *Eryngium yuccifolium* and *Lacinaria spicata.*

Cornus amomum Mill. **Dogwood family (Cornaceae).**

Synonym.—*Cornus sericea* L.

Red osier; swamp-dogwood; silky cornel; rose-willow.

Native shrub, 3 to 10 feet high; in low woods and along streams, Canada to Florida, west to Texas and the Dakotas.

Part used.—Bark (nonofficial).

Cornus circinata L'Her. **Dogwood family (Cornaceae).**

Green osier; round-leaved dogwood.

Native shrub, 3 to 10 feet high; in shady places, Canada and the northeastern United States.

Part used.—Bark (nonofficial).

Cornus florida L. **Dogwood family (Cornaceae).**

Flowering dogwood; boxwood.

Small, native tree or large shrub, growing in woods from Canada to Florida, Texas and Missouri. Most abundant in the Middle States.

Parts used.—Bark of tree and of root, the latter preferred (nonofficial).

Cornus sericea L. Same as *Cornus amomum.*

Corydalis canadensis Goldie. Same as *Bikukulla canadensis.*

Corydalis formosa Pursh. Same as *Bikukulla canadensis.*

Cotton-gum. See *Nyssa aquatica.*

Cottonweed. See *Anaphalis margaritacea.*

Couch-grass. See *Agropyron repens.*

Coughweed. See *Senecio aureus.*

Coughwort. See *Tussilago farfara.*

Cowbane, spotted. See *Conium maculatum.*

Cow-lily. See *Nymphaea advena.*

Cow-parsnip. See *Heracleum lanatum.*

Cracca virginiana L. **Pea family (Fabaceae).**

Synonym.—*Tephrosia virginiana* Pers.

Devil's-shoestring; hoary pea; goat's-rue; catgut.

Hoary, perennial herb, 1 to 2 feet high, native; occurring in dry, sandy soil from New England to Florida, west to Texas and Minnesota.

Part used.—Root (nonofficial).

Cramp-bark. See *Viburnum opulus.*

Cranberry, high-bush. See *Viburnum opulus.*

Cranberry, upland-. See *Arctostaphylos uva-ursi.*

Crane's-bill, spotted. See *Geranium maculatum.*

Crane's-bill, wild. See *Geranium maculatum.*

Crataegus oxyacantha L. **Apple family (Malaceae).**

Hawthorn; hedgethorn; whitethorn; maythorn.

Shrub or tree, introduced from Europe, and sparingly escaped from cultivation.

Part used.—Berries (nonofficial).

Crawley-root. See *Corallorhiza odontorhiza.*

Crosswort. See *Eupatorium perfoliatum.*

Cucumber-tree. See *Magnolia acuminata* and *M. tripetala.*

Cudweed, low. See *Gnaphalium uliginosum.*

Cudweed, marsh-. See *Gnaphalium uliginosum.*

Culver's-physic. See *Veronica virginica.*

Culver's-root. See *Veronica virginica.*

Cunila mariana L. Same as *Cunila origanoides.*

Cunila origanoides (L.) Britton. **Mint family (Menthaceae).**

Synonym.—*Cunila mariana* L.

American dittany; stonemint.

Indigenous, perennial plant, found on dry hills and in dry woods from New York to Florida, west to Ohio.

Part used.—Herb (nonofficial).

Cup-plant. See *Silphium perfoliatum.*

Custard-apple. See *Asimina triloba.*

Cynoglossum officinale L. **Borage family (Boraginaceae).**

Hound's-tongue; gypsy-flower.

Biennial herb, about 3 feet high, naturalized from Europe, and occurring in waste places from Canada to North Carolina, west to Kansas and Minnesota.

Parts used.—Leaves and root (nonofficial).

Cypripedium. See *Cypripedium hirsutum* and *C. parviflorum.*

Cypripedium hirsutum Mill. **Orchid family (Orchidaceae).**

Synonym.—Cypripedium pubescens Willd.

Cypripedium; large yellow ladies-slipper; yellow moccasin-flower; American valerian.

Herb, 1 to 2 feet high, native in woods and thickets from Nova Scotia south to Alabama and west to Nebraska and Missouri.

Parts used.—Rhizome and roots (official).

Cypripedium parviflorum Salisb. **Orchid family (Orchidaceae).**

Cypripedium; small yellow ladies-slipper.

Herb, 1 to 2 feet high; native in woods and thickets from British America to Georgia, Missouri, and Oregon.

Parts used.—Rhizome and roots (official).

Cypripedium pubescens Willd. Same as *Cypripedium hirsutum.*

Cytisus scoparius (L.) Link. **Pea family (Fabaceae).**

Synonym.—Sarothamnus scoparius Wimm.

Scoparius; broom; green broom; Scotch broom.

Stiff, wiry plant, 3 to 5 feet high; naturalized from Europe; growing in dry, sandy soil from Massachusetts to Virginia and becoming common in many places in the northwestern United States.

Part used.—Tops (official).

Daisy, oxeye. See *Chrysanthemum leucanthemum.*

Daisy, white. See *Chrysanthemum leucanthemum.*

Daisy-fleabane. See *Erigeron philadelphicus.*

Damiana. See *Turnera microphylla.*

Dandelion. See *Taraxacum officinale.*

Daphne mezereum L. **Mezereon family (Daphnaceae).**

Synonym.—Mezereum officinarum C. A. Mey.

Mezereum; mezereon; spurge-laurel; paradise-plant; spurge-olive.

A very hardy shrub, introduced from Europe and escaped from cultivation in Canada and New England.

Part used.—Bark of this and of other European species of Daphne (official).

Datura stramonium L. **Potato family (Solanaceae).**

Stramonium; jimson-weed; Jamestown-weed; thorn-apple; apple-of-Peru.

Poisonous weed; annual, 2 to 5 feet high; introduced from the Tropics, and occurring in fields and waste places throughout the United States, with the exception of the North and West.

Parts used.—Leaves (official); seeds (official in U. S. P. 1890).

Daucus carota L. **Parsley family (Apiaceae).**

Wild carrot; Queen-Anne's-lace.

Biennial herb, 2 to 3 feet high; naturalized from Europe; common almost throughout the United States, growing in old fields and along roadsides.

Parts used.—Root, fruit, and leaves (nonofficial).

Deerberry. See *Gaultheria procumbens* and *Mitchella repens.*

Deer-laurel. See *Rhododendron maximum.*

Deer's-tongue. See *Trilisa odoratissima.*

Deerwood. See *Ostrya virginiana.*

Deerwort-boneset. See *Eupatorium ageratoides.*

Delphinium consolida L. **Crowfoot family (Ranunculaceae).**

Field-larkspur; knight's-spur; lark-heel.

An annual herb, about 2 feet high; naturalized from Europe, and found in waste places from southern New Jersey and Pennsylvania southward. The indig-

Delphinium consolida—Continued.

enous tall larkspur, *Delphinium urceolatum* Jacq. (*D. exaltatum* Ait.), is used for similar purposes. This is found in woods from Pennsylvania to Minnesota, south to Alabama and Nebraska.

Parts used.—Herb and seeds (nonofficial).

Delphinium exaltatum Ait. See under *Delphinium consolida.*

Delphinium urceolatum Jacq. See under *Delphinium consolida.*

Devil's-bit. See *Lacinaria scariosa.*

Devil's-shoestring. See *Cracca virginiana.*

Dewberry. See *Rubus procumbens.*

Dewberry, one-flowered. See *Rubus villosus.*

Dewberry, southern. See *Rubus trivialis.*

Dicentra canadensis Walp. Same as *Bikukulla canadensis.*

Digitalis. See *Digitalis purpurea.*

Digitalis purpurea L. **Figwort family (Scrophulariaceae).**

Digitalis; foxglove; fairy-fingers; thimbles; lady's-glove.

Very handsome biennial plant, 3 to 4 feet high; introduced from Europe as a garden plant, and now escaped from cultivation in parts of Oregon, Washington, and West Virginia.

Parts used.—Leaves from plants of second year's growth, gathered at commencement of flowering (official).

Dioscorea villosa L. **Yam family (Dioscoreaceae).**

Wild yam; colic-root; rheumatism-root.

Slender, herbaceous, native vine, growing in moist thickets from Rhode Island to Minnesota, south to Florida and Texas; more common in central and southern parts of the United States.

Part used.—Rhizome (nonofficial).

Diospyros virginiana L. **Ebony family (Diospyraceae).**

Persimmon.

Indigenous tree, 15 to 50 feet in height; in fields and woods, Rhode Island to Kansas, Florida, and Texas.

Parts used.—Bark and unripe fruit (nonofficial).

Dirca palustris L. **Mezereon family (Daphnaceae).**

Leatherwood; moosewood; American mezereon; wickopy; rope-bark.

A native shrub, occurring in woods and thickets, New Brunswick to Florida, west to Missouri and Minnesota; most common in the Northern and Eastern States.

Part used.—Bark (nonofficial).

Ditch-stonecrop. See *Penthorum sedoides.*

Dittany, American. See *Cunila origanoides.*

Dock, bitter. See *Rumex obtusifolius.*

Dock, blunt-leaved. See *Rumex obtusifolius.*

Dock, broad-leaved. See *Rumex obtusifolius.*

Dock, curled. See *Rumex crispus.*

Dock, narrow. See *Rumex crispus.*

Dock, sour. See *Rumex crispus.*

Dock, spatter-. See *Nymphaea advena.*

Dock, velvet. See *Verbascum thapsus.*

Dock, yellow. See *Rumex crispus.*

Dogbane, spreading. See *Apocynum androsaemifolium.*

Dogberry. See *Sorbus americana.*

Dog-fennel. See *Anthemis cotula.*

Dog-grass. See *Agropyron repens.*

Dog's-tooth violet. See *Erythronium americanum.*

Dogwood, flowering. See *Cornus florida.*

Dogwood, round-leaved. See *Cornus circinata.*

Dogwood, swamp-. See *Cornus amomum.*

Dooryard-plantain. See *Plantago major.*

Dracontium foetidum L. Same as *Spathyema foetida.*

Dragon's-claw. See *Corallorhiza odontorhiza.*

Dropwort, western. See *Porteranthus trifoliatus.*

Drosera rotundifolia L. **Sundew family (Droseraceae).**

Round-leaved sundew; youthwort.

Low, perennial herb, growing in bogs and muddy shores of rivers from Canada to Florida and California.

Part used.—Herb (nonofficial).

Dryopteris filix-mas (L.) Schott. **Fern family (Polypodiaceae).**

Synonyms.—Aspidium filix-mas Sw.; *Polypodium filix-mas* L.

Aspidium; male-fern.

Fern, with leaves 1 to 3 feet long; in rocky woods from Canada to northern Michigan, and in the Rocky Mountains to Arizona.

Part used.—Rhizome (official).

Dryopteris marginalis (L.) A. Gray. **Fern family (Polypodiaceae).**

Synonyms.—Aspidium marginale Sw.; *Polypodium marginale* L.

Aspidium; evergreen wood-fern; marginal-fruited shield-fern.

Fern, with leaves 6 inches to 2½ feet long; in rocky woods from Canada south to Alabama and Arkansas.

Part used.—Rhizome (official).

Dulcamara. See *Solanum dulcamara.*

Dysentery-weed. See *Gnaphalium uliginosum.*

Earth-smoke. See *Fumaria officinalis.*

Echinacea. See *Brauneria angustifolia.*

Echinacea angustifolia DC. Same as *Brauneria angustifolia.*

Elder. See *Sambucus canadensis.*

Elder, American. See *Sambucus canadensis.*

Elder, dwarf. See *Aralia hispida.*

Elder, sweet. See *Sambucus canadensis.*

Elder, wild. See *Aralia hispida.*

Elecampane. See *Inula helenium.*

Elk-tree. See *Oxydendrum arboreum.*

Elkwood. See *Magnolia tripetala.*

Elliott's-sabbatia. See *Sabbatia elliottii.*

Elm. See *Ulmus fulva.*

Elm, Indian. See *Ulmus fulva.*

Elm, moose-. See *Ulmus fulva.*

Elm, red. See *Ulmus fulva.*

Elm, slippery. See *Ulmus fulva.*

Emetic-root. See *Euphorbia corollata.*

Epigaea repens L. **Heath family (Ericaceae).**

Gravel-plant; trailing arbutus; mayflower.

Small, shrubby, native plant, spreading on the ground in sandy soil, especially under evergreen trees, from Florida to Michigan and northward.

Part used.—Leaves (nonofficial).

Epilobium angustifolium L. Same as *Chamaenerion angustifolium.*

Epilobium palustre L. **Evening-primrose family (Onagraceae).**

Swamp willow-herb; wickup.

Slender, erect, native herb, 6 to 18 inches high, found in swamps and marshes from Canada and the New England States west to Colorado and Washington.

Parts used.—Leaves and root (nonofficial).

Epiphegus virginiana Bart. Same as *Leptamnium virginianum.*

Equisetum hyemale L. **Horsetail family (Equisetaceae).**

Common scouring-rush; horsetail; shave-grass.

Rush-like perennial plant, growing in wet places along river banks and borders of woods throughout nearly the whole of North America.

Part used.—Plant (nonofficial).

Erechtites hieracifolia (L.) Raf. **Aster family (Asteraceae).**

Fireweed; pilewort.

Native, annual herb, 1 to 8 feet high, in woods, fields, and waste places, Canada to Florida, Louisiana, and Nebraska.

Part used.—Herb (nonofficial).

Erigeron canadensis L. **Aster family (Asteraceae).**

Synonym.—*Leptilon canadense* (L.) Britton.[a]

Canada fleabane; horseweed; colt's-tail; prideweed; bitterweed.

Native, annual weed, 3 inches to 10 feet in height; in fields and meadows, along roadsides, and in waste places, almost throughout North America.

Part used.—Herb (nonofficial); the oil of erigeron, distilled from the fresh, flowering herb, is official.

Erigeron philadelphicus L. **Aster family (Asteraceae).**

Philadelphia fleabane; sweet scabious; daisy-fleabane.

Native, perennial herb, 1 to 3 feet high, in fields and woods throughout North America, except extreme North.

Part used.—Herb (nonofficial).

Eriodictyon. See *Eriodictyon californicum.*

Eriodictyon californicum (H. & A.) Greene. **Waterleaf family (Hydrophyllaceae).**

Synonym.—*Eriodictyon glutinosum* Benth.

Eriodictyon; yerba santa; mountain-balm; consumptive's-weed; bear's-weed.

Shrubby plant, 2 to 4 feet high, native; grows in clumps in dry situations and among rocks throughout California and northern Mexico.

Part used.—Leaves (official).

Eriodictyon glutinosum Benth. Same as *Eriodictyon californicum.*

Eryngium yuccaefolium Michx. Same as *Eryngium yuccifolium.*

Eryngium yuccifolium Michx. **Parsley family (Apiaceae).**

Synonym.—*Eryngium yuccaefolium* Michx.

Water-eryngo; button-snakeroot; rattlesnake-weed; rattlesnake-master; corn-snakeroot.

Native, perennial herb, 1 to 5 feet high, growing in swamps and low wet ground from the pine barrens of New Jersey west to Minnesota, and south to Texas and Florida.

Part used.—Rhizome (nonofficial).

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[a] Some authors hold that this plant belongs to the genus *Leptilon* and that its name should be *Leptilon canadense* (L.) Britton. The Pharmacopœia is here followed.

Eryngo, water-. See *Eryngium yuccifolium.*

Erythronium americanum Ker. **Lily family (Liliaceae).**

Yellow adder's-tongue; dog's-tooth violet; yellow snowdrop; rattlesnake-violet; yellow snakeleaf.

Native, perennial herb, occurring in moist woods and thickets, Nova Scotia to Minnesota, south to Arkansas and Florida.

Parts used.—Leaves and root (nonofficial).

Euonymus. See *Euonymus atropurpureus.*

Euonymus atropurpureus Jacq. **Staff-tree family (Celastraceae).**

Euonymus; wahoo; burningbush; spindle-tree; Indian arrowwood.

Native shrub or small tree, growing in woods and thickets from Ontario and eastern United States west to Montana.

Part used.—Bark of root (official).

Eupatorium. See *Eupatorium perfoliatum.*

Eupatorium ageratoides L. f. **Aster family (Asteraceae).**

White snakeroot; white sanicle; Indian sanicle; deerwort-boneset; poolwort; poolroot; richweed; squaw-weed.

Erect, perennial herb, 1 to 4 feet high, native; in rich woods from Canada to Georgia, west to Nebraska and Louisiana.

Part used.—Root (nonofficial).

Eupatorium aromaticum L. **Aster family (Asteraceae).**

Smaller white snakeroot; poolwort; poolroot; wild hoarhound.

Native, perennial herb, 1 to 2 feet high; in dry soil from Massachusetts to Florida, especially throughout the Middle States.

Part used.—Root (nonofficial).

Eupatorium perfoliatum L. **Aster family (Asteraceae).**

Eupatorium; boneset; thoroughwort; Indian sage; agueweed; crosswort.

Native, perennial herb, 1 to 5 feet high; in low, wet places from Canada to Florida, west to Texas and Nebraska.

Parts used.—Leaves and flowering tops (official).

Eupatorium purpureum L. **Aster family (Asteraceae).**

Queen-of-the-meadow; gravelroot; Joe-Pye-weed; purple boneset; kidneyroot.

Native, perennial herb, 3 to 10 feet high; in low grounds from Canada to Florida and Texas.

Parts used.—Root and herb (nonofficial).

Euphorbia corollata L. **Spurge family (Euphorbiaceae).**

Flowering spurge; emetic-root; milk-ipecac; snakemilk; purging-root.

Native, perennial herb, about 3 feet in height, growing in dry fields and woods from Ontario to Florida and Minnesota to Texas.

Part used.—Root (nonofficial).

Euphorbia hypericifolia A. Gray. Same as *Euphorbia nutans.*

Euphorbia ipecacuanhae L. **Spurge family (Euphorbiaceae).**

Wild ipecac; ipecac-spurge; American ipecac; Carolina ipecac.

Native, perennial herb, 4 to 10 inches high; in dry, sandy soil, mostly near the coast, from Connecticut to Florida.

Part used.—Root (nonofficial).

Euphorbia nutans Lag. **Spurge family (Euphorbiaceae).**

Synonym.—*Euphorbia hypericifolia* A. Gray.

Large spotted spurge; black purslane; fluxweed; milk-purslane.

Native, annual plant, from ½ to 2 feet in height; in rich soils, fields, and thickets throughout eastern North America, except extreme north, and extending west to the Rocky Mountains.

Part used.—Herb (nonofficial).

Euphorbia pilulifera L. **Spurge family (Euphorbiaceae).**

Pill-bearing spurge; snakeweed; Queensland asthma-weed.

Herbaceous annual, 10 to 15 inches high, occurring from the Gulf States through Texas to New Mexico.

Part used.—Herb (nonofficial).

Evening-primrose. See *Oenothera biennis.*

Everlasting. See *Anaphalis margaritacea.*

Everlasting, large-flowered. See *Anaphalis margaritacea.*

Everlasting, pearly. See *Anaphalis margaritacea.*

Eve's-cup. See *Sarracenia flava.*

Fagara clava-herculis (L.) Small. **Rue family (Rutaceae).**

Synonym.—*Xanthoxylum clava-herculis* L.

Xanthoxylum; southern prickly ash; toothache-tree; yellowthorn; yellowwood; Hercules-club.

Small, indigenous, very prickly tree, sometimes 45 feet in height, occurring along streams from southern Virginia to Florida, west to Texas and Arkansas.

Parts used.—Bark official under the name "Xanthoxylum"; berries (nonofficial).

Fagus americana Sweet. **Beech family (Fagaceae).**

Synonym.—*Fagus ferruginea* Ait.

American beech; beechnut-tree.

Large, native forest tree, growing in rich soil from Nova Scotia to Florida, west to Wisconsin and Texas.

Parts used.—Bark and leaves (nonofficial).

Fagus ferruginea Ait. Same as *Fagus americana.*

Fairy-fingers. See *Digitalis purpurea.*

Featherfew. See *Chrysanthemum parthenium.*

Febrifuge-plant. See *Chrysanthemum parthenium.*

Female-fern. See *Athyrium filix-foemina* and *Polypodium vulgare.*

Fennel, dog-. See *Anthemis cotula.*

Fern, evergreen wood-. See *Dryopteris marginalis.*

Fern, female-. See *Athyrium filix-foemina* and *Polypodium vulgare.*

Fern, lady-. See *Athyrium filix-foemina.*

Fern, maidenhair-. See *Adiantum pedatum.*

Fern, male-. See *Dryopteris filix-mas.*

Fern, marginal-fruited shield-. See *Dryopteris marginalis.*

Fern, meadow-. See *Comptonia peregrina.*

Fern, parsley-. See *Tanacetum vulgare.*

Fern, royal. See *Osmunda regalis.*

Fern, sweet. See *Comptonia peregrina.*

Fernroot. See *Polypodium vulgare.*

Feverbush. See *Benzoin benzoin* and *Ilex verticillata.*

Feverfew, common. See *Chrysanthemum parthenium.*

Feverroot. See *Triosteum perfoliatum.*

Fevertwig. See *Celastrus scandens.*

Field-balm. See *Glecoma hederacea.*

Field-larkspur. See *Delphinium consolida.*

Field-sorrel. See *Rumex acetosella.*

Figwort, Maryland. See *Scrophularia marilandica.*

Fir, balsam-. See *Abies balsamea.*

Fireweed. See *Erechtites hieracifolia.*

Fit-plant. See *Monotropa uniflora.*

Fitroot. See *Monotropa uniflora.*

Fivefinger. See *Potentilla canadensis.*

Flag, blue. See *Iris versicolor.*

Flag, cattail-. See *Typha latifolia.*

Flag, sweet-. See *Acorus calamus.*

Flag, water-. See *Iris versicolor.*

Flag-lily. See *Iris versicolor.*

Flannel-leaf. See *Verbascum thapsus.*

Fleabane, Canada. See *Erigeron canadensis.*

Fleabane, daisy-. See *Erigeron philadelphicus.*

Fleabane, Philadelphia. See *Erigeron philadelphicus.*

Fluxweed. See *Euphorbia nutans.*

Flytrap. See *Sarracenia purpurea.*

Foamflower. See *Tiarella cordifolia.*

Foxglove. See *Digitalis purpurea.*

Fragaria virginiana Duchesne. **Rose family (Rosaceae).**

Virginia strawberry; scarlet strawberry.

Native, perennial herb, occurring in dry soil from Canada to Georgia, west to Indian Territory and Minnesota.

Part used.—Leaves (nonofficial).

Frankenia grandifolia Cham. & Schlecht. **Frankenia family (Frankeniaceae).**

Yerba reuma.

Native, perennial herb, 8 to 13 inches high, common in salt marshes and sandy localities near the coast in California.

Part used.—Herb (nonofficial).

Frasera carolinensis Walt. **Gentian family (Gentianaceae).**

Synonym.—*Frasera walteri* Michx.

American columbo; Indian lettuce; meadowpride; pyramid-flower.

Smooth, perennial herb, 3 to 8 feet high, found in dry soil from New York to Wisconsin, south to Georgia and Kentucky.

Part used.—Root (nonofficial).

Frasera walteri Michx. Same as *Frasera carolinensis.*

Fraxinus acuminata Lam. Same as *Fraxinus americana.*

Fraxinus alba Marsh. Same as *Fraxinus americana.*

Fraxinus americana L. **Olive family (Oleaceae).**

Synonyms.—*Fraxinus alba* Marsh; *Fraxinus acuminata* Lam.

White ash; cane-ash.

Large, native forest tree, in rich woods from Nova Scotia to Minnesota, south to Florida and Texas. Occurs chiefly in the Northern States and Canada.

Part used.—Bark (nonofficial).

Fraxinus nigra Marsh. **Olive family (Oleaceae).**

Synonym.—*Fraxinus sambucifolia* Lam.

Black ash; hoop-ash.

Native tree, 40 to 70 feet in height, occurring in swamps and wet woods from Canada to Virginia and Arkansas.

Part used.—Bark (nonofficial).

Fraxinus sambucifolia Lam. Same as *Fraxinus nigra*.

Fringe-tree. See *Chionanthus virginica*.

Frost-plant. See *Helianthemum canadense*.

Frostweed. See *Helianthemum canadense*.

Frostwort. See *Helianthemum canadense*.

Fuller's-herb. See *Saponaria officinalis*.

Fumaria officinalis L. **Poppy family (Papaveraceae).**

Fumitory; hedge-fumitory; earth-smoke.

Annual plant, 10 to 15 inches high, adventive from Europe and found in waste places about dwellings, in cultivated land, and on ballast, Nova Scotia to the Gulf States.

Part used.—Herb (nonofficial).

Fumitory. See *Fumaria officinalis*.

Fumitory, hedge-. See *Fumaria officinalis*.

Gagroot. See *Lobelia inflata*.

Gale, sweet. See *Myrica gale*.

Galium aparine L. **Madder family (Rubiaceae).**

Cleavers; goose-grass; cleaverwort; bedstraw; catchweed.

Annual plant, with weak, procumbent stem, 2 to 6 feet long, growing in shady thickets and margins of woods, New Brunswick south to Florida and Texas. Naturalized from Europe.

Part used.—Herb of this and of other species of Galium (nonofficial).

Gallweed. See *Gentiana quinquefolia*.

Garden-balm. See *Melissa officinalis*.

Garden-celandine. See *Chelidonium majus*.

Garden-columbine. See *Aquilegia vulgaris*.

Garden-valerian. See *Valeriana officinalis*.

Garget. See *Phytolacca decandra*.

Gaultheria procumbens L. **Heath family (Ericaceae).**

Wintergreen; checkerberry; mountain-tea; teaberry; deerberry.

Small, native perennial, with evergreen leaves, found in sandy soils in cool, damp woods, especially under evergreen trees, in Canada and the northeastern United States.

Part used.—Leaves (nonofficial); the oil of gaultheria, distilled from the leaves, is official.

Gay-feather. See *Lacinaria scariosa* and *L. spicata*.

Gelsemium. See *Gelsemium sempervirens*.

Gelsemium sempervirens (L.) Ait. f. **Logania family (Loganiaceae).**

Gelsemium; yellow jasmine; Carolina jasmine; wild woodbine.

Twining, shrubby perennial, native, growing on low ground in woods and thickets from eastern Virginia to Florida and Texas, mostly near the coast.

Parts used.—Rhizome and roots (official).

Gemfruit. See *Tiarella cordifolia*.

Gentian, American. See *Gentiana saponaria*.

Gentian, blue. See *Gentiana saponaria*.

Gentian, five-flowered. See *Gentiana quinquefolia*.

Gentian, horse-. See *Triosteum perfoliatum*.

Gentian, marsh-. See *Gentiana villosa*.

Gentian, snake-. See *Nabalus serpentarius*.

Gentian, soapwort-. See *Gentiana saponaria.*

Gentian, stiff. See *Gentiana quinqlefolia.*

Gentian, straw-colored. See *Gentiana villosa.*

Gentian, striped. See *Gentiana villosa.*

Gentian, white. See *Triosteum perfoliatum.*

Gentiana catesbaei Walt. Same as *Gentiana saponaria.*

Gentiana ochroleuca Froel. Same as *Gentiana villosa.*

Gentiana quinqueflora Lam. Same as *Gentiana quinquefolia.*

Gentiana quinquefolia L. **Gentian family (Gentianaceae).**

Synonym.—*Gentiana quinqueflora* Lam.

Stiff gentian; five-flowered gentian; agueweed; gallweed.

Native, annual plant, 1 to 2 feet in height, growing in pastures and other open situations from Maine to Michigan, south to Florida and Missouri.

Parts used.—Root and herb (nonofficial).

Gentiana saponaria L. **Gentian family (Gentianaceae).**

Synonym.—*Gentiana catesbaei* Walt.

American gentian; blue gentian; soapwort-gentian.

Native, perennial herb, 1 to 2½ feet high; in wet soil, Ontario to Minnesota, south to Louisiana and Florida.

Part used.—Root (nonofficial).

Gentiana villosa L. **Gentian family (Gentianaceae).**

Synonym.—*Gentiana ochroleuca* Froel.

Striped gentian; straw-colored gentian; marsh-gentian; Sampson's-snakeroot.

Native, perennial herb, 6 to 18 inches high; in shaded places, Middle and Southern States.

Part used.—Root (nonofficial).

Geranium. See *Geranium maculatum.*

Geranium maculatum L. **Geranium family (Geraniaceae).**

Geranium; wild crane's-bill; spotted crane's-bill; wild geranium; spotted geranium; alum-root.

Native, perennial herb, 1 to 1½ feet high; found in low grounds and open woods from Canada south to Georgia and Missouri.

Part used.—Rhizome (official).

Geranium, spotted. See *Geranium maculatum.*

Geranium, wild. See *Geranium maculatum.*

Geum rivale L. **Rose family (Rosaceae).**

Water-avens; purple avens.

Native, perennial herb, 1 to 2 feet high, occurring in swamps and wet meadows from Canada to Pennsylvania and Colorado, especially in the Northern and Middle States.

Parts used.—Rhizome and rootlets (nonofficial).

Ghostflower. See *Monotropa uniflora.*

Gillenia trifoliata Moench. Same as *Porteranthus trifoliatus.*

Gill-over-the-ground. See *Glecoma hederacea.*

Ginger, Indian. See *Asarum canadense.*

Ginger, wild. See *Asarum canadense.*

Gingerroot. See *Tussilago farfara.*

Ginseng. See *Panax quinquefolium.*

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Glecoma hederacea L. **Mint family (Menthaceae).**

Synonym.—*Nepeta glechoma* Benth.

Ground-ivy; gill-over-the-ground; catfoot; field-balm.

Low, perennial herb, with creeping stem. Naturalized from Europe and found in waste places, woods, and thickets from Newfoundland to Minnesota, south to Georgia and Kansas.

Part used.—Herb (nonofficial).

Globeflower. See *Cephalanthus occidentalis.*

Gnaphalium margaritaceum L. Same as *Anaphalis margaritacea.*

Gnaphalium obtusifolium L. **Aster family (Asteraceae).**

Synonym.—*Gnaphalium polycephalum* Michx.

Sweet balsam; life-everlasting; sweet life-everlasting; white balsam.

Native, herbaceous annual, 1 to 2 feet high; in dry, open places and old fields from Nova Scotia and Manitoba south to Florida and Texas.

Part used.—Herb (nonofficial).

Gnaphalium polycephalum Michx. Same as *Gnaphalium obtusifolium.*

Gnaphalium uliginosum L. **Aster family (Asteraceae).**

Mouse-ear; low cudweed; marsh-cudweed; wartwort; dysentery-weed.

Annual herb, 2 to 8 inches high, occurring in damp soil from Newfoundland to Minnesota, south to Indiana and Virginia; apparently naturalized from Europe.

Part used.—Herb (nonofficial).

Gnaphalium undulatum Walt. Same as *Pterocaulon undulatum.*

Goat's-rue. See *Cracca virginiana.*

Goldenrod, anise-scented. See *Solidago odora.*

Goldenrod, fragrant-leaved. See *Solidago odora.*

Goldenrod, sweet. See *Solidago odora.*

Goldenseal. See *Hydrastis canadensis.*

Goldthread. See *Coptis trifolia.*

Goodyera pubescens R. Br. Same as *Peramium pubescens.*

Goodyera repens R. Br. Same as *Peramium repens.*

Goose-grass. See *Galium aparine.*

Grape, Oregon. See *Berberis aquifolium.*

Grape, Rocky Mountain. See *Berberis aquifolium.*

Gravel-plant. See *Epigaea repens.*

Gravelroot. See *Eupatorium purpureum.*

Gravel-weed. See *Onosmodium virginianum.*

Greenbrier, long-stalked. See *Smilax pseudo-china.*

Grindelia. See *Grindelia robusta* and *G. squarrosa.*

Grindelia robusta Nutt. **Aster family (Asteraceae).**

Grindelia; gum-plant.

Perennial herb, about 1½ feet high, native in the States west of the Rocky Mountains.

Parts used.—Leaves and flowering tops (official).

Grindelia, scaly. See *Grindelia squarrosa.*

Grindelia squarrosa (Pursh) Dunal. **Aster family (Asteraceae).**

Grindelia; scaly grindelia; broad-leaved gum-plant.

Perennial herb, 1 to 2 feet high, native; occurring on the plains and prairies from the Saskatchewan to Minnesota, Texas, and California.

Parts used.—Leaves and flowering tops (official).

Gromwell, Virginia false. See *Onosmodium virginianum*

Ground-centaury. See *Polygala nuttallii.*

Ground-ivy. See *Glecoma hederacea.*

Ground-raspberry. See *Hydrastis canadensis.*

Ground-squirrel pea. See *Jeffersonia diphylla.*

Gum, cotton-. See *Nyssa aquatica.*

Gum, red. See *Liquidambar styraciflua.*

Gum, star-leaved. See *Liquidambar styraciflua.*

Gum, sweet-. See *Liquidambar styraciflua.*

Gum, tupelo. See *Nyssa aquatica.*

Gum-plant. See *Grindelia robusta.*

Gum-plant, broad-leaved. See *Grindelia squarrosa.*

Gypsy-flower. See *Cynoglossum officinale.*

Gypsy-weed. See *Lycopus virginicus.*

Hackmatack. See *Larix laricina.*

Haircap-moss. See *Polytrichum juniperinum.*

Hamamelis. See *Hamamelis virginiana.*

Hamamelis virginiana L. **Witch-hazel family (Hamamelidaceae).**

Hamamelis; witch-hazel; winterbloom; snapping hazel.

Indigenous shrub, found in low, damp woods from New Brunswick to Minnesota, south to Florida and Texas.

Parts used.—Leaves (collected in autumn), bark, and twigs (official).

Hardhack. See *Spiraea tomentosa.*

Hart's-thorn. See *Rhamnus cathartica.*

Haw, black. See *Viburnum prunifolium.*

Hawkweed, early. See *Hieracium venosum.*

Hawthorn. See *Crataegus oxyacantha.*

Hazel, snapping. See *Hamamelis virginiana.*

Heal-all. See *Prunella vulgaris* and *Scrophularia marilandica.*

Healing-herb. See *Symphytum officinale.*

Heart-liverleaf. See *Hepatica acuta.*

Heartsease. See *Viola tricolor.*

Hedeoma. See *Hedeoma pulegioides.*

Hedeoma pulegioides (L.) Pers. **Mint family (Menthaceae).**

Hedeoma; American pennyroyal; tickweed; squawmint.

Low, native, annual plant, 6 to 12 inches high, growing in barren woods and dry fields, Nova Scotia to Minnesota, south to Nebraska and Florida.

Parts used.—Leaves and flowering tops, and the volatile oil distilled from these, are official.

Hedge-fumitory. See *Fumaria officinalis.*

Hedgethorn. See *Crataegus oxyacantha.*

Helenium autumnale L. **Aster family (Asteraceae).**

Sneezeweed; sneezewort; swamp-sunflower.

Native perennial, 2 to 3 feet high, growing in swamps, wet fields, and meadows, Canada to Florida and Arizona.

Part used.—Herb (nonofficial).

Helianthemum canadense (L.) Michx. **Rock-rose family (Cistaceae).**

Frostweed; frostwort; frost-plant; Canadian rock-rose.

Native, perennial herb, about one foot in height; in dry, sandy soil, Maine to Wisconsin, south to North Carolina and Kentucky.

Part used.—Herb (nonofficial).

Hellebore, American. See *Veratrum viride.*

Hellebore, green. See *Veratrum viride.*

Hellebore, swamp-. See *Veratrum viride.*

Helmetpod. See *Jeffersonia diphylla.*

Helonias dioica Pursh. Same as *Chamaelirium luteum.*

Hemlock. See *Tsuga canadensis.*

Hemlock, poison-. See *Conium maculatum.*

Hemlock, water-. See *Cicuta maculata.*

Hemlock-spruce. See *Tsuga canadensis.*

Hemp, black Indian. See *Apocynum cannabinum.*

Hemp, Canadian. See *Apocynum cannabinum.*

Hemp, white Indian. See *Asclepias incarnata.*

Henbane. See *Hyoscyamus niger.*

Hepatica acuta (Pursh) Britton. **Crowfoot family (Ranunculaceae).**

Synonym.—*Hepatica acutiloba* DC.

Heart-liverleaf; sharp-lobed liverleaf; liverwort.

Perennial herb, 4 to 9 inches high, found in woods from Quebec and Ontario, south to Georgia (but rare near the coast), west to Iowa and Minnesota.

Part used.—Leaves (nonofficial).

Hepatica acutiloba DC. Same as *Hepatica acuta.*

Hepatica hepatica (L.) Karst. **Crowfoot family (Ranunculaceae).**

Synonym.—*Hepatica triloba* Chaix.

Round-lobed liverleaf; kidney-liverleaf; liverwort.

Perennial herb, 4 to 6 inches high; in woods from Nova Scotia to northern Florida, west to Iowa and Missouri; less common than the heart-liverleaf.

Part used.—Leaves (nonofficial).

Hepatica triloba Chaix. Same as *Hepatica hepatica.*

Heracleum lanatum Michx. **Parsley family (Apiaceae).**

Masterwort; cow-parsnip; youthwort.

Native, perennial herb, 3 to 5 feet high, growing in moist meadows and cultivated ground from Canada south to North Carolina, Utah, and California.

Parts used.—Root, leaves, and seeds (nonofficial).

Hercules-club. See *Fagara clava-herculis.*

Heuchera americana L. **Saxifrage family (Saxifragaceae).**

Alum-root; American sanicle.

Native, perennial herb, 2 to 4 feet in height; in shady, rocky woodlands from Connecticut to Minnesota, south to Alabama and Louisiana.

Part used.—Root (nonofficial).

Hickory, shellbark-. See *Hicoria ovata.*

Hicoria ovata (Mill.) Britton. **Walnut family (Juglandaceae).**

Synonym.—*Carya alba* Nutt.

Shagbark, shellbark-hickory.

Large, native tree, sometimes 120 feet in height; in rich soil from Quebec to southern Ontario and Minnesota, south to Florida and Texas.

Parts used.—Bark and leaves (nonofficial).

Hieracium venosum L. **Chicory family (Cichoriaceae).**

Early hawkweed; rattlesnake-weed; bloodwort; striped bloodwort.

Perennial herb, 1 to 2 feet high, native; occurring in dry woods and thickets from Maine to Georgia, west to Nebraska; more common in the northern and eastern United States.

Parts used.—Leaves and root (nonofficial).

Highbelia. See *Lobelia siphilitica.*

Hive-vine. See *Mitchella repens.*

Hoarhound. See *Marrubium vulgare.*

Hoarhound, water-. See *Lycopus virginicus.*

Hoarhound, wild. See *Eupatorium aromaticum.*

Hog-potato. See *Ipomoea pandurata.*

Hog's-bean. See *Hyoscyamus niger.*

Hogweed. See *Ambrosia artemisiaefolia.*

Holly, American. See *Ilex opaca.*

Holly, white. See *Ilex opaca.*

Honeybloom. See *Apocynum androsaemifolium.*

Hoodwort. See *Scutellaria lateriflora.*

Hoop-ash. See *Fraxinus nigra.*

Hop-hornbeam. See *Ostrya virginiana.*

Hop-tree. See *Ptelea trifoliata.*

Hornbeam, hop-. See *Ostrya virginiana.*

Horse-balm. See *Collinsonia canadensis.*

Horse-chestnut. See *Aesculus hippocastanum.*

Horsefly-weed. See *Baptisia tinctoria.*

Horsefoot. See *Tussilago farfara.*

Horse-gentian. See *Triosteum perfoliatum.*

Horseheal. See *Inula helenium.*

Horsemint. See *Monarda fistulosa* and *M. punctata.*

Horse-nettle. See *Solanum carolinense.*

Horsetail. See *Equisetum hyemale.*

Horseweed. See *Erigeron canadensis.*

Hound's-tongue. See *Cynoglossum officinale.*

Hydrangea. See *Hydrangea arborescens.*

Hydrangea arborescens L. **Hydrangea family (Hydrangeaceae).**

Hydrangea; wild hydrangea; seven-barks.

Indigenous shrub, 5 or 6 feet in height; on rocky river banks from southern New York to Florida, west to Iowa and Missouri; very abundant in the valley of the Delaware.

Part used.—Root (nonofficial).

Hydrangea, wild. See *Hydrangea arborescens.*

Hydrastis. See *Hydrastis canadensis.*

Hydrastis canadensis L. **Crowfoot family (Ranunculaceae).**

Hydrastis; goldenseal; yellowroot; ground-raspberry; orangeroot; yellow puccoon.

Perennial herb, about 1 foot in height, native in rich soil in shady woods, southern New York to Minnesota, south to Georgia and Missouri, but principally in Ohio, Indiana, Kentucky, and West Virginia.

Parts used.—Rhizome and roots (official).

Hyoscyamus. See *Hyoscyamus niger.*

Hyoscyamus niger L. **Potato family (Solanaceae).**

Hyoscyamus; henbane; hog's-bean; insane-root.

Biennial herb, 6 inches to 2 feet high, sparingly naturalized from Europe, in waste places from Nova Scotia to Ontario, New York, and Michigan.

Parts used.—Leaves and flowering tops from plants of second year's growth (official); seeds are also used (nonofficial).

Hypericum perforatum L. **St. John's-wort family (Hypericaceae).**

John's-wort; common St. John's-wort.

Herbaceous perennial, 1 to 2 feet high, naturalized from Europe; common in fields and waste places throughout almost the entire United States, except the Southern States.

Part used.—Herb (nonofficial).

Hyssop. See *Hyssopus officinalis.*

Hyssop, wild. See *Verbena hastata.*

Hyssop-skullcap. See *Scutellaria integrifolia.*

Hyssopus officinalis L. **Mint family (Menthaceae).**

Hyssop.

Perennial herb, 1 to 3 feet high, naturalized from Europe, and found along roadsides and in waste places from Ontario and Maine to North Carolina, and on the Pacific coast.

Part used.—Herb (nonofficial).

Ilex opaca Ait. **Holly family (Aquifoliaceae).**

American holly; white holly.

Native tree, 20 to 40 feet in height, with evergreen leaves; in moist woodlands, Maine to Florida, and west to Missouri and Texas; most abundant in the Atlantic States.

Parts used.—Leaves and bark (nonofficial).

Ilex verticillata (L.) A. Gray. **Holly family (Aquifoliaceae).**

Synonym.—*Prinos verticillata* L.

Black alder; feverbush; Virginia winterberry.

A native shrub, growing in moist woods and along banks of streams from Nova Scotia to Florida, west to Wisconsin and Missouri.

Parts used.—Bark and berries (nonofficial).

Impatiens aurea Muhl. **Jewelweed family (Impatientaceae).**

Synonym.—*Impatiens pallida* Nutt.

Jewelweed; pale touch-me-not; snapweed; wild celandine.

Native, annual plant, 2 to 4 feet high, found in rich soil in moist, shady places from Quebec to Oregon, south to Georgia and Kansas.

Part used.—Herb (nonofficial).

Impatiens biflora Walt. **Jewelweed family (Impatientaceae).**

Synonym.—*Impatiens fulva* Nutt.

Jewelweed; spotted touch-me-not; snapweed; silverleaf.

Native, annual plant, 2 to 5 feet high, growing in rich soil in moist, shady places from Canada to Alaska and Oregon, south to Florida and Missouri; more common than the pale touch-me-not.

Part used.—Herb (nonofficial).

Impatiens fulva Nutt. Same as *Impatiens biflora.*

Impatiens pallida Nutt. Same as *Impatiens aurea.*

Indian-cup. See *Silphium perfoliatum.*

Indian-paint. See *Sanguinaria canadensis.*

Indian-physic. See *Porteranthus trifoliatus.*

Indian-pipe. See *Monotropa uniflora.*

Indian-root. See *Aralia racemosa.*

Indigo, American. See *Baptisia tinctoria.*

Indigo, wild. See *Baptisia tinctoria.*

Indigo, yellow. See *Baptisia tinctoria.*

Indigo-weed. See *Baptisia tinctoria.*

Inkberry. See *Phytolacca decandra.*

Inkroot. See *Limonium carolinianum.*

Insane-root. See *Hyoscyamus niger.*

Inula. See *Inula helenium.*

Inula helenium L. **Aster family (Asteraceae).**

Inula; elecampane; horseheal; scabwort.

Rough, perennial herb, 3 to 6 feet high, naturalized from Europe, and found along roadsides and in fields and pastures from Nova Scotia to North Carolina, westward to Missouri and Minnesota.

Part used.—Root (official in U. S. P. 1890).

Ipecac, American. See *Euphorbia ipecacuanhae.*

Ipecac, Carolina. See *Euphorbia ipecacuanhae.*

Ipecac, false. See *Porteranthus trifoliatus.*

Ipecac, milk-. See *Euphorbia corollata.*

Ipecac, wild. See *Euphorbia ipecacuanhae* and *Triosteum perfoliatum.*

Ipecac-spurge. See *Euphorbia ipecacuanhae.*

Ipomoea pandurata (L.) Meyer. **Morning-glory family (Convolvulaceae).**

Synonym.—*Convolvulus panduratus* L.

Manroot; man-of-the-earth; wild potato; hog-potato; wild jalap.

Native perennial, with trailing stems 2 to 12 feet long; in dry fields or on hills from Connecticut to Michigan, south to Florida and Texas.

Part used.—Root (nonofficial).

Iris. See *Iris versicolor.*

Iris versicolor L. **Iris family (Iridaceae).**

Iris; blue flag; flag-lily; liver-lily; water-flag; snake-lily.

Native, perennial plant, 2 to 3 feet high, found in wet, marshy localities from Newfoundland to Manitoba, south to Florida and Arkansas.

Parts used.—Rhizome and roots (official in U. S. P. 1890).

Ironwood. See *Ostrya virginiana.*

Ivy, American. See *Parthenocissus quinquefolia.*

Ivy, ground-. See *Glecoma hederacea.*

Ivy, poison-. See *Rhus radicans* and *R. toxicodendron.*

Jack-in-the-pulpit. See *Arisaema triphyllum.*

Jacob's-ladder. See *Polemonium reptans.*

Jacob's-ladder, American. See *Smilax herbacea.*

Jalap, wild. See *Ipomoea pandurata.*

James-tea. See *Ledum groenlandicum.*

Jamestown-weed. See *Datura stramonium.*

Jasmine, Carolina. See *Gelsemium sempervirens.*

Jasmine, yellow. See *Gelsemium sempervirens.*

Jeffersonia diphylla (L.) Pers. **Barberry family (Berberidaceae).**

Twinleaf; rheumatism-root; helmetpod; yellowroot; ground-squirrel pea.

Native, perennial plant, 8 to 14 inches in height, growing in woods and near streams from New York to Virginia, westward to Wisconsin.

Part used.—Rhizome (nonofficial).

Jewelweed. See *Impatiens aurea* and *I. biflora.*

Jimson-weed. See *Datura stramonium.*

Job's-tears, wild. See *Onosmodium virginianum.*

Joe-Pye-weed. See *Eupatorium purpureum.*

John's-wort. See *Hypericum perforatum.*

Judas-tree. See *Cercis canadensis.*

Juglans. See *Juglans cinerea.*

Juglans cinerea L. **Walnut family (Juglandaceae).**

Juglans; butternut; white walnut.

Indigenous tree, 20 to 50 feet in height, common in rich woods from New Brunswick to North Dakota, south to Georgia, Mississippi, and Arkansas.

Part used.—Bark of root, collected in autumn (official in U. S. P. 1890).

Juniper. See *Juniperus communis.*

Juniperus communis L. **Pine family (Pinaceae).**

Juniper.

Evergreen shrub or low tree, common on dry, sterile hills from Canada south to New Jersey, west to Nebraska, and in the Rocky Mountains to New Mexico.

Part used.—Fruit (nonofficial). The oil of juniper, distilled from the fruit, is official.

Juniperus sabina L. **Pine family (Pinaceae).**

Sabina; savin; shrubby red cedar.

A shrub, usually procumbent, seldom more than 4 feet in height, occurring in rocky places in the northern United States.

Part used.—Tops, and the oil of savin, distilled from the fresh tops, are official.

Juniperus virginiana L. **Pine family (Pinaceae).**

Red cedar; red savin.

A tree, sometimes 100 feet in height, common in dry soil from Canada to Florida and Arizona.

Parts used.—Leaves and "cedar apples" (nonofficial).

Kalmia angustifolia L. **Heath family (Ericaceae).**

Sheep-laurel; lambkill; calfkill; narrow-leaved laurel.

Native, evergreen shrub, about 3 feet high, growing in moist soil from Canada south to Georgia.

Part used.—Leaves (nonofficial).

Kalmia latifolia L. **Heath family (Ericaceae).**

Mountain-laurel; calico-bush; broad-leaved laurel; sheep-laurel.

Native, evergreen shrub, 10 to 20 feet high, growing in sandy or rocky soil from New Brunswick to Ohio, Florida, and Louisiana.

Part used.—Leaves (nonofficial).

Kidney-liverleaf. See *Hepatica hepatica.*

Kidneyroot. See *Eupatorium purpureum.*

Knight's-spur. See *Delphinium consolida.*

Knobroot. See *Collinsonia canadensis.*

Knotweed, biting. See *Polygonum hydropiper.*

Koellia montana (Michx.) Kuntze. **Mint family (Menthaceae).**

Synonym.—Pycnanthemum montanum Michx.

Thin-leaved mountain-mint.

Native perennial, 2 to 3 feet high, found in woods from southern Virginia to Georgia and Alabama.

Part used.—Herb (nonofficial).

Koellia pilosa (Nutt.) Britton. **Mint family (Menthaceae).**

Synonym.—Pycnanthemum pilosum Nutt.

Hairy mountain-mint.

Native perennial, 1 to 2½ feet high, occurring in prairies and dry woods from Ohio to Georgia, west to Missouri and Arkansas.

Part used.—Herb (nonofficial).

Lacinaria scariosa (L.) Hill. **Aster family (Asteraceae).**

Synonym.—Liatris scariosa Willd.

Blue blazingstar; large button-snakeroot; rattlesnake-master; gay-feather; devil's-bit.

Native, perennial herb, 4 to 5 feet high, found in dry woods and sandy fields from Maine to Florida, west to Texas and Nebraska.

Part used.—Root (nonofficial).

Lacinaria spicata (L.) Kuntze. **Aster family (Asteraceae).**

Synonym.—Liatris spicata Willd.

Dense button-snakeroot; colic-root; prairie-pine; gay-feather; rattlesnake-master; corn-snakeroot; backache-root.

Native, perennial herb, 2 to 5 feet high, in moist places from Massachusetts to Florida, west to Wisconsin and Arkansas.

Part used.—Root (nonofficial).

Lacinaria squarrosa (L.) Hill. **Aster family (Asteraceae).**

Synonym.—Liatris squarrosa Willd.

Scaly blazingstar; colic-root; rattlesnake-master (in the South).

Native, perennial herb, 2 to 3 feet high, in dry soil, Ontario to Florida, west to Nebraska and Texas.

Part used.—Root (nonofficial).

Lactuca canadensis L. **Chicory family (Cichoriaceae).**

Synonym.—Lactuca elongata Muhl.

Wild lettuce; tall lettuce; wild opium; trumpet-milkweed.

Annual or biennial plant, 3 to 10 feet in height, native in moist, open places, British America south to Georgia and Louisiana.

Part used.—Herb (nonofficial).

Lactuca elongata Muhl. Same as *Lactuca canadensis.*

Ladies-slipper, large yellow. See *Cypripedium hirsutum.*

Ladies-slipper, small yellow. See *Cypripedium parviflorum.*

Lady-fern. See *Athyrium filix-foemina.*

Lady's-glove. See *Digitalis purpurea.*

Lambkill. See *Kalmia angustifolia.*

Lappa. See *Arctium lappa.*

Lappa major Gaertn. Same as *Arctium lappa.*

Larch, American. See *Larix laricina.*

Larch, black. See *Larix laricina.*

Larix americana Michx. Same as *Larix laricina.*

Larix laricina (Du Roi) Koch. **Pine family (Pinaceae).**

Synonym.—*Larix americana* Michx.

Tamarack; American larch; hackmatack; black larch.

A tall, slender tree, native in swampy woods and moist places from Canada south to New Jersey, Indiana, and Minnesota.

Part used.—Bark (nonofficial).

Lark-heel. See *Delphinium consolida.*

Larkspur, field-. See *Delphinium consolida.*

Larkspur, tall. See under *Delphinium consolida.*

Laurel, broad-leaved. See *Kalmia latifolia.*

Laurel, deer-. See *Rhododendron maximum.*

Laurel, great. See *Rhododendron maximum.*

Laurel, mountain-. See *Kalmia latifolia.*

Laurel, narrow-leaved. See *Kalmia angustifolia.*

Laurel, rose-. See *Rhododendron maximum.*

Laurel, sheep-. See *Kalmia angustifolia* and *K. latifolia.*

Laurel, spurge-. See *Daphne mezereum.*

Laurel, swamp-. See *Magnolia virginiana.*

Laurus benzoin L. Same as *Benzoin benzoin.*

Lavender, sea-. See *Limonium carolinianum.*

Leafcup, yellow. See *Polymnia uvedalia.*

Leatherwood. See *Dirca palustris.*

Ledum groenlandicum Oeder. **Heath family (Ericaceae).**

Synonym.—*Ledum latifolium* Ait.

Labrador tea; continental tea; James-tea.

Evergreen shrub, 1 to 4 feet high, native in cold bogs and damp mountain woods, northern part of the United States and in Canada.

Part used.—Leaves (nonofficial).

Ledum latifolium Ait. Same as *Ledum groenlandicum.*

Lemon, wild. See *Podophyllum peltatum.*

Lemon-balm. See *Melissa officinalis.*

Leonurus cardiaca L. **Mint family (Menthaceae).**

Motherwort; lion's-tail; throwwort.

Perennial plant, 2 to 5 feet high, naturalized from Europe, and occurring in fields and waste places from Nova Scotia to North Carolina westward to Nebraska.

Part used.—Herb (nonofficial).

Leptamnium virginianum (L.) Raf. **Broomrape family (Orobanchaceae).**

Synonyms.—*Epiphegus virginiana* Bart.; *Orobanche virginiana* L.

Beechdrops; cancerroot.

Plant 6 inches to 2 feet in height, parasitic upon the roots of beech trees from New Brunswick to Florida, west to Michigan and Louisiana.

Part used.—Whole plant (nonofficial).

Leptandra. See *Veronica virginica.*

Leptandra virginica (L.) Nutt. Same as *Veronica virginica.*

Leptilon canadense (L.) Britton. Same as *Erigeron canadensis.*

Lettuce, Indian. See *Frasera carolinensis.*

Lettuce, tall. See *Lactuca canadensis.*

Lettuce, white. See *Nabalus albus* and *N. serpentarius.*

Lettuce, wild. See *Lactuca canadensis.*

Leucanthemum vulgare Lam. Same as *Chrysanthemum leucanthemum.*

Leverwood. See *Ostrya virginiana.*

Liatris odoratissima Michx. Same as *Trilisa odoratissima.*

Liatris scariosa Willd. Same as *Lacinaria scariosa.*

Liatris spicata Willd. Same as *Lacinaria spicata.*

Liatris squarrosa Willd. Same as *Lacinaria squarrosa.*

Life-everlasting. See *Anaphalis margaritacea* and *Gnaphalium obtusifolium.*

Life-everlasting, sweet. See *Gnaphalium obtusifolium.*

Liferoot. See *Senecio aureus.*

Ligustrum vulgare L. **Olive family (Oleaceae).**

Privet; primwort; prim.

A shrub, 5 or 6 feet high, introduced from Europe; escaped from cultivation and grows wild in woods and along roadsides from Ontario to Pennsylvania and North Carolina.

Part used.—Leaves (nonofficial).

Lily, cow-. See *Nymphaea advena.*

Lily, flag-. See *Iris versicolor.*

Lily, large yellow pond-. See *Nymphaea advena.*

Lily, liver-. See *Iris versicolor.*

Lily, snake-. See *Iris versicolor.*

Lily, sweet-scented water-. See *Castalia odorata.*

Lily, water-. See *Castalia odorata.*

Lily, white pond-. See *Castalia odorata.*

Lily-of-the-valley. See *Convallaria majalis.*

Lime, Ogeechee. See *Nyssa ogeche.*

Limonium carolinianum (Walt.) Britton.

Plumbago family (Plumbaginaceae).

Synonym.—*Statice caroliniana* Walt.

Marsh-rosemary; inkroot; sea-lavender; cankerroot.

Native, perennial herb, 1 to 2 feet high, in salt meadows on the Atlantic and Gulf coasts.

Part used.—Root (nonofficial).

Linden, American. See *Tilia americana.*

Lindera benzoin Meissn. Same as *Benzoin benzoin.*

Lion's-foot. See *Nabalus albus* and *N. serpentarius.*

Lion's-tail. See *Leonurus cardiaca.*

Liquidambar styraciflua L. **Witch-hazel family (Hamamelidaceae).**

Sweet-gum; star-leaved gum; red gum.

Large, native tree, 80 to 140 feet high, in moist woods from Connecticut to Florida, Illinois, and Missouri. Most common near the coast in the Middle and Southern States.

Parts used.—Bark and resin (nonofficial).

Liriodendron tulipifera L. **Magnolia family (Magnoliaceae).**

Tulip-tree; yellow poplar; whitewood; tulip-poplar; canoewood.

An indigenous tree, 60 to 190 feet in height, growing in rich woods from New England to Florida, west to Michigan and Arkansas; reaches greatest size in the Middle and Southern States.

Part used.—Bark of trunk and of root (nonofficial).

Lithospermum virginianum L. Same as *Onosmodium virginianum.*

Liverleaf, heart-. See *Hepatica acuta.*

Liverleaf, kidney-. See *Hepatica hepatica.*

Liverleaf, round-lobed. See *Hepatica hepatica.*

Liverleaf, sharp-lobed. See *Hepatica acuta.*

Liver-lily. See *Iris versicolor.*

Liverwort. See *Hepatica acuta* and *H. hepatica.*

Lobelia. See *Lobelia inflata.*

Lobelia, blue. See *Lobelia siphilitica.*

Lobelia cardinalis L. **Bellflower family (Campanulaceae).**

Cardinal-flower; red cardinal; red lobelia.

Native, perennial herb, 2 to 4 feet high, with showy scarlet flowers; in moist soil from British America south to Florida and Texas.

Part used.—Herb (nonofficial).

Lobelia, great. See *Lobelia siphilitica.*

Lobelia inflata L. **Bellflower family (Campanulaceae).**

Lobelia; Indian tobacco; gagroot; vomitwort; bladderpod.

Native, annual, herbaceous plant, 1 to 3 feet high, poisonous; in dry soil, fields, old pastures, and along roadsides from Canada to Georgia, Nebraska, and Arkansas.

Parts used.—Leaves and tops, collected after a portion of the capsules have become inflated (official). The seeds are also used (nonofficial).

Lobelia, red. See *Lobelia cardinalis.*

Lobelia siphilitica L. **Bellflower family (Campanulaceae).**

Blue cardinal-flower; great lobelia; blue lobelia; highbelia.

Native, perennial herb, about 1 to 3 feet high, growing in moist soil from Ontario to Georgia, west to Louisiana and the Dakotas.

Part used.—Herb (nonofficial).

Locust, black. See *Robinia pseudacacia.*

Locust, yellow. See *Robinia pseudacacia.*

Locust-plant. See *Cassia marilandica.*

Locust-tree. See *Robinia pseudacacia.*

Lycopodium. See *Lycopodium clavatum.*

Lycopodium clavatum L. **Club-moss family (Lycopodiaceae).**

Lycopodium; club-moss; stag's-horn.

Native perennial, with trailing stem, growing in dry situations in woods from Canada to North Carolina, Michigan, and Washington.

Part used.—Spores of this or of other species of Lycopodium (official).

Lycopus virginicus L. **Mint family (Menthaceae).**

Bugleweed; sweet bugle; water-bugle; gypsy-weed; water-hoarhound.

Indigenous, perennial herb, 10 to 20 inches in height; in wet, shady places from Canada to Florida, Missouri, and Nebraska.

Part used.—Herb (nonofficial).

Madweed. See *Scutellaria lateriflora.*

Magnolia acuminata L. **Magnolia family (Magnoliaceae).**

Cucumber-tree; mountain-magnolia; blue magnolia.

Native tree, 60 to 80 feet in height, occurring in the mountainous regions from New York to Georgia. More abundant in the Southern States.

Part used.—Bark (nonofficial).

Magnolia, blue. See *Magnolia acuminata.*

Magnolia glauca L. Same as *Magnolia virginiana.*

Magnolia, mountain-. See *Magnolia acuminata.*

Magnolia, sweet. See *Magnolia virginiana.*

Magnolia tripetala L. **Magnolia family (Magnoliaceae).**

Synonym.—*Magnolia umbrella* Lam.

Cucumber-tree; umbrella-tree; elkwood.

A small native tree, not more than 40 feet high, growing in rather moist, rich soil; widely distributed in the Appalachian Mountain region, but nowhere very common.

Part used.—Bark (nonofficial).

Magnolia umbrella Lam. Same as *Magnolia tripetala.*

Magnolia virginiana L. **Magnolia family (Magnoliaceae).**

Synonym.—*Magnolia glauca* L.

White bay; sweet bay; sweet magnolia; beaver-tree; swamp-sassafras; swamp-laurel.

A native tree, averaging about 25 feet in height, growing in swamps and morasses, Massachusetts to the Gulf of Mexico.

Part used.—Bark (nonofficial).

Maidenhair-fern. See *Adiantum pedatum.*

Male-fern. See *Dryopteris filix-mas.*

Mallow, common. See *Malva sylvestris.*

Mallow, dwarf. See *Malva rotundifolia.*

Mallow, high. See *Malva sylvestris.*

Mallow, low. See *Malva rotundifolia.*

Mallow, running. See *Malva rotundifolia.*

Malva rotundifolia L. **Mallow family (Malvaceae).**

Low mallow; running mallow; cheeses; dwarf mallow.

Annual or biennial procumbent plant, naturalized from Europe, and widely distributed as a weed in waste places.

Parts used.—Leaves and flowers (nonofficial).

Malva sylvestris L. **Mallow family (Malvaceae).**

High mallow; common mallow; cheeseflower.

Biennial herb; adventive from Europe; sparingly distributed in the United States and Canada, growing in waste places and along roadsides.

Part used.—Flowers (nonofficial).

Mandrake, American. See *Podophyllum peltatum.*

Mandrake, wild. See *Podophyllum peltatum.*

Man-of-the-earth. See *Ipomoea pandurata.*

Manroot. See *Ipomoea pandurata.*

Manzanita. See *Arctostaphylos glauca.*

Maple, red. See *Acer rubrum.*

Maple, swamp-. See *Acer rubrum.*

Maple, vine-. See *Menispermum canadense.*

Marrubium. See *Marrubium vulgare.*

Marrubium vulgare L. **Mint family (Menthaceae).**

Marrubium; hoarhound.

Bushy, perennial herb, 1 to 3 feet high, naturalized from Europe, and growing in dry, sandy soil, in fields and waste places, from Maine southward to Texas and westward to California and Oregon.

Parts used.—Leaves and flowering tops (official).

Marsh-cudweed. See *Gnaphalium uliginosum.*

Marsh-gentian. See *Gentiana villosa.*

Marshmallow. See *Althaea officinalis.*

Marsh-rosemary. See *Limonium carolinianum.*

Marsh-trefoil. See *Menyanthes trifoliata.*

Maruta cotula DC. Same as *Anthemis cotula.*

Masterwort. See *Angelica atropurpurea* and *Heracleum lanatum.*

May-apple. See *Podophyllum peltatum.*

Mayflower. See *Epigaea repens.*

May-pops. See *Passiflora incarnata.*

Maythorn. See *Crataegus oxyacantha.*

Mayweed. See *Anthemis cotula.*

Meadow-clover. See *Trifolium pratense.*

Meadow-fern. See *Comptonia peregrina.*

Meadowpride. See *Frasera carolinensis.*

Meadow-scabish. See *Aster puniceus.*

Meadowsweet, pink. See *Spiraea tomentosa.*

Mealy-tree. See *Viburnum dentatum.*

Melilot, yellow. See *Melilotus officinalis.*

Melilotus officinalis (L.) Lam. **Pea family (Fabaceae).**

Yellow melilot; yellow sweet clover.

Annual or biennial herb, 1 to 3 feet high, introduced from Europe, and occurring in waste places throughout the eastern United States.

Parts used.—Leaves and flowering tops (nonofficial).

Melissa. See *Melissa officinalis.*

Melissa officinalis L. **Mint family (Menthaceae).**

Melissa; balm; lemon-balm; garden-balm; sweet balm.

Perennial herb, 10 to 20 inches high, naturalized from Europe, and growing in waste places, fields, and woods from Maine to Georgia.

Parts used.—Leaves and tops (official in U. S. P. 1890).

Menispermum. See *Menispermum canadense.*

Menispermum canadense L. **Moonseed family (Menispermaceae).**

Menispermum; yellow parilla; Canada moonseed; Texas sarsaparilla; vine-maple.

Native, perennial, woody climber, found in woods along streams from Canada to Georgia and Arkansas.

Parts used.—Rhizome and roots (official in U. S. P. 1890).

Mentha piperita. See *Mentha piperita* L.

Mentha piperita L. **Mint family (Menthaceae).**

Mentha piperita; peppermint.

Aromatic, perennial herb, 1 to 2 feet high, naturalized from Europe, and occurring in damp places from Nova Scotia to Minnesota, south to Florida and Tennessee. Cultivated principally in Michigan and New York.

Parts used.—Leaves and flowering tops, and the oil of peppermint distilled from these, are official.

Mentha spicata L. **Mint family (Menthaceae).**

Synonym.—*Mentha viridis* L.

Mentha viridis; spearmint.

Aromatic, perennial herb, 1 to 2 feet high, naturalized from Europe, and growing in moist fields and waste places from Nova Scotia to Utah, south to Florida and Kansas. Also cultivated.

Parts used.—Leaves and flowering tops, and the oil of spearmint distilled from these, are official.

Mentha viridis. See *Mentha spicata.*

Mentha viridis L. Same as *Mentha spicata.*

Menyanthes trifoliata L. **Buck-bean family (Menyanthaceae).**

Buck-bean; bog-bean; marsh-trefoil; water-shamrock.

Indigenous, perennial plant, about 1 foot in height, found in spongy, boggy soils and swamps from Canada and Alaska south to Pennsylvania, Minnesota, and California.

Parts used.—Rhizome and leaves (nonofficial).

Mezereon. See *Daphne mezereum.*

Mezereon, American. See *Dirca palustris.*

Mezereum. See *Daphne mezereum.*

Mezereum officinarum C. A. Mey. Same as *Daphne mezereum.*

Micromeria chamissonis (Benth.) Greene. **Mint family (Menthaceae).**

Synonym.—*Micromeria douglasii* Benth.

Yerba buena.

A trailing, perennial herb, common in woods along the Pacific coast of the United States.

Part used.—Plant (nonofficial).

Micromeria douglasii Benth. Same as *Micromeria chamissonis.*

Milfoil. See *Achillea millefolium.*

Milk-ipecac. See *Euphorbia corollata.*

Milk-purslane. See *Euphorbia nutans.*

Milkweed, common. See *Asclepias syriaca.*

Milkweed, swamp-. See *Asclepias incarnata.*

Milkweed, trumpet-. See *Lactuca canadensis.*

Milkwort, Nuttall's-. See *Polygala nuttallii.*

Mint, hairy mountain-. See *Koellia pilosa.*

Mint, mountain-. See *Monarda didyma.*

Mint, thin-leaved mountain-. See *Koellia montana.*

Mistletoe. See *Phoradendron flavescens.*

Mistletoe, American. See *Phoradendron flavescens.*

Mitchella repens L. **Madder family (Rubiaceae).**

Squaw-vine; checkerberry; partridgeberry; deerberry; hive-vine; squawberry.

Small, creeping, evergreen herb, common in moist woods from Nova Scotia to Minnesota, south to Florida and Arkansas.

Part used.—Plant (nonofficial).

Miterwort, false. See *Tiarella cordifolia.*

Moccasin-flower, yellow. See *Cypripedium hirsutum.*

Mohawk-weed. See *Uvularia perfoliata.*

Monarda didyma L. **Mint family (Menthaceae).**

Bee-balm; Oswego tea; mountain-mint; scarlet balm.

Native perennial, 2 to 3 feet high, growing in moist soil, especially along streams, from New Brunswick to Michigan and south to Georgia.

Part used.—Herb (nonofficial).

Monarda fistulosa L. **Mint family (Menthaceae).**

Wild bergamot; horsemint.

Native perennial, 2 to 3 feet high, found on dry hills and in thickets from Ontario south to Florida and Louisiana.

Part used.—Herb (nonofficial).

Monarda punctata L. **Mint family (Menthaceae).**

Horsemint.

Native, perennial herb, 2 to 3 feet high, found in dry, sandy fields from New York to Florida, west to Wisconsin and Texas.

Part used.—Herb (nonofficial).

Monotropa uniflora L. **Indian-pipe family (Monotropaceae).**

Indian-pipe; fit-plant; fitroot; ghostflower; pipe-plant.

A curious plant, white in all its parts, growing in rich, moist woods from Canada to Florida, westward to Washington and California.

Part used.—Root (nonofficial).

Moonseed, Canada. See *Menispermum canadense.*

Moose-elm. See *Ulmus fulva.*

Moosewood. See *Dirca palustris.*

Mortification-root. See *Althaea officinalis.*

Moss, club-. See *Lycopodium clavatum.*

Moss, haircap-. See *Polytrichum juniperinum.*

Motherwort. See *Leonurus cardiaca.*

Mountain-ash, American. See *Sorbus americana.*

Mountain-balm. See *Eriodictyon californicum.*

Mountain-laurel. See *Kalmia latifolia.*

Mountain-magnolia. See *Magnolia acuminata.*

Mountain-mint. See *Monarda didyma.*

Mountain-mint, hairy. See *Koellia pilosa.*

Mountain-mint, thin-leaved. See *Koellia montana.*

Mountain-sumac. See *Sorbus americana.*

Mountain-tea. See *Gaultheria procumbens.*

Mouse-ear. See *Gnaphalium uliginosum.*

Mouthroot. See *Coptis trifolia.*

Mugwort, common. See *Artemisia vulgaris.*

Mullein. See *Verbascum thapsus.*

Musquash-root. See *Cicuta maculata.*

Mustard, black. See *Brassica nigra.*

Mustard, brown. See *Brassica nigra.*

Mustard, red. See *Brassica nigra.*

Mustard, white. See *Sinapis alba.*

Mustard, yellow. See *Sinapis alba.*

Myrica asplenifolia L. Same as *Comptonia peregrina.*

Myrica cerifera L. **Bayberry family (Myricaceae).**

Bayberry; wax-myrtle; candleberry; waxberry.

Grows in sandy swamps or wet woods from Florida and Texas northward to Maryland. In the South it is a small evergreen tree, becoming in its northward range a tall, semi-deciduous shrub, or a dwarfed and deciduous shrub.

Parts used.—Bark of root, leaves, and berries (nonofficial).

Myrica gale L. **Bayberry family (Myricaceae).**

Sweet gale; Dutch myrtle; bog-myrtle; golden osier.

Indigenous shrub, growing in swamps and along streams from Canada and Alaska to Virginia and Washington.

Parts used.—Leaves and buds (nonofficial).

Myrtle, bog-. See *Myrica gale.*

Myrtle, Dutch. See *Myrica gale.*

Myrtle, wax-. See *Myrica cerifera.*

Nabalus albus (L.) Hook. **Chicory family (Cichoriaceae).**

Synonym.—Prenanthes alba L.

Lion's-foot; rattlesnake-root; white lettuce; white canker-weed.

Native, perennial herb, 2 to 4 feet high, common in rich, moist woods from Canada to Georgia and Kentucky.

Part used.—Plant (nonofficial).

Nabalus serpentarius (Pursh) Hook. **Chicory family (Cichoriaceae).**

Synonym.—Prenanthes serpentaria Pursh.

Lion's-foot; canker-weed; white lettuce; rattlesnake-root; snake-gentian.

Native, perennial herb, about 2 feet high, growing in dry, sandy soil in fields and thickets from Ontario to Florida and Alabama.

Part used.—Plant (nonofficial).

Nannybush. See *Viburnum lentago.*

Necklace-weed. See *Actaea alba* and *Onosmodium virginianum.*

Nepeta cataria L. **Mint family (Menthaceae).**

Catnip; catmint.

Common, perennial weed, 2 to 3 feet high, naturalized from Europe; found in waste places and cultivated land from Canada to Minnesota, south to Virginia and Arkansas.

Part used.—Herb (nonofficial).

Nepeta glechoma Benth. Same as *Glecoma hederacea.*

Netleaf-plantain. See *Peramium pubescens.*

Netleaf-plantain, smaller. See *Peramium repens.*

Nettle, bull-. See *Solanum carolinense.*

Nettle, great. See *Urtica dioica.*

Nettle, horse-. See *Solanum carolinense.*

Nettle, stinging. See *Urtica dioica.*

Niggerhead. See *Brauneria angustifolia.*

Nightshade, woody. See *Solanum dulcamara.*

Nuphar advena R. Br. Same as *Nymphaea advena.*

Nuttall's-milkwort. See *Polygala nuttallii.*

Nymphaea advena Soland. **Water-lily family (Nymphaeaceae).**

Synonym.—Nuphar advena R. Br.

Large yellow pond-lily; cow-lily; spatter-dock; beaverroot.

An aquatic plant, found in ponds and slow streams from Canada to Florida, and westward to the Rocky Mountains.

Part used.—Rhizome (nonofficial).

Nymphaea odorata Dryand. Same as *Castalia odorata.*

Nyssa aquatica L. **Dogwood family (Cornaceae).**

Synonym.—Nyssa uniflora Wang.

Large tupelo; cotton-gum; tupelo gum.

A large, native tree, occurring in swamps from southern Virginia to Florida, west to Texas and Missouri.

Part used.—Root wood (nonofficial).

Nyssa capitata Walt. Same as *Nyssa ogeche.*

Nyssa ogeche Marsh. **Dogwood family (Cornaceae).**

Synonym.—*Nyssa capitata* Walt.

Sour tupelo; Ogeechee lime.

A small tree, growing in swamps near the seacoast from southern South Carolina to Florida.

Part used.—Root wood (nonofficial).

Nyssa uniflora Wang. Same as *Nyssa aquatica.*

Oak, champion-. See *Quercus rubra.*

Oak, Jerusalem. See *Chenopodium anthelminticum* and *C. botrys.*

Oak, poison-. See *Rhus radicans* and *R. toxicodendron.*

Oak, red. See *Quercus rubra.*

Oak, Spanish. See *Quercus rubra.*

Oak, stone-. See *Quercus alba.*

Oak, white. See *Quercus alba.*

Oenothera biennis L. **Evening-primrose family (Onagraceae).**

Synonym.—*Onagra biennis* (L.) Scop.

Evening-primrose; tree-primrose; night willow-herb.

Annual or biennial plant, 2 to 5 feet high, common in fields and waste places from Labrador to Florida, west to the Rocky Mountains. Native.

Part used.—Plant (nonofficial).

Old-man's-beard. See *Chionanthus virginica.*

Olive, spurge-. See *Daphne mezereum.*

Onagra biennis (L.) Scop. Same as *Oenothera biennis.*

Onosmodium virginianum (L.) DC. **Borage family (Boraginaceae).**

Synonym.—*Lithospermum virginianum* L.

Virginia false gromwell; gravel-weed; necklace-weed; pearl-plant; wild Job's-tears.

Rough-hairy, native, perennial herb, 1 to 2 feet high; in dry, hilly grounds from the New England States to Florida, Kansas, and Texas.

Parts used.—Root and seeds (nonofficial).

Opium, wild. See *Lactuca canadensis.*

Orangeroot. See *Hydrastis canadensis.*

Orobanche virginiana L. Same as *Leptamnium virginianum.*

Osier, golden. See *Myrica gale.*

Osier, green. See *Cornus circinata.*

Osier, red. See *Cornus amomum.*

Osmorrhiza longistylis DC. Same as *Washingtonia longistylis.*

Osmunda regalis L. **Royal fern family (Osmundaceae).**

Royal fern; buckhorn-brake.

A tall, native fern, with fronds 3 to 4 feet high, occurring in swamps and marshes from Canada to Florida and Mississippi.

Part used.—Rhizome (nonofficial).

Ostrya virginiana (Mill.) Willd. **Birch family (Betulaceae).**

Hop-hornbeam; ironwood; deerwood; leverwood.

Native tree, 25 to 30 feet in height, growing in rich woods, Canada and eastern United States.

Part used.—Bark (nonofficial).

Oxalis acetosella L. **Wood-sorrel family (Oxalidaceae).**

White wood-sorrel; shamrock; sour trefoil.

Small, native, perennial herb, found in cold, damp woods, Canada south to Michigan and North Carolina.

Part used.—Herb (nonofficial).

Oxeye daisy. See *Chrysanthemum leucanthemum.*

Oxydendrum arboreum (L.) DC. **Heath family (Ericaceae).**

Synonym.—Andromeda arborea L.

Sourwood; sorrel-tree; elk-tree.

Native tree, sometimes 40 to 50 feet in height, growing in rich woods from Ohio to Maryland, south to Alabama and Florida.

Parts used.—Leaves and bark (nonofficial)

Palmetto, saw-. See *Serenoa serrulata.*

Panax quinquefolium L. **Ginseng family (Araliaceae).**

Ginseng.

Native, perennial herb, about 1 foot in height, found in rich, shady woods from the Middle and Northern States south to Alabama and Georgia.

Part used.—Root (nonofficial).

Pansy. See *Viola tricolor.*

Papoose-root. See *Caulophyllum thalictroides.*

Paradise-plant. See *Daphne mezereum.*

Parilla, yellow. See *Menispermum canadense.*

Parsley, spotted. See *Conium maculatum.*

Parsley-fern. See *Tanacetum vulgare.*

Parsnip, cow-. See *Heracleum lanatum.*

Parthenocissus quinquefolia (L.) Planch. **Grape family (Vitaceae).**

Synonym.—Ampelopsis quinquefolia Michx.

American ivy; Virginia creeper.

A common, woody vine, native in woods and thickets from Canada to Florida and Texas.

Parts used.—Bark and young twigs (nonofficial).

Partridgeberry. See *Mitchella repens.*

Pasqueflower, American. See *Pulsatilla hirsutissima.*

Passiflora incarnata L. **Passion-flower family (Passifloraceae).**

Passion-flower; passion-vine; may-pops.

Climbing, perennial plant, native in dry soil from Virginia to Florida, westward to Missouri and Arkansas.

Parts used.—Root and stem base (nonofficial).

Passion-flower. See *Passiflora incarnata.*

Passion-vine. See *Passiflora incarnata.*

Paul's-betony. See *Veronica officinalis.*

Pawpaw, North American. See *Asimina triloba.*

Pea, ground-squirrel. See *Jeffersonia diphylla.*

Pea, hoary. See *Cracca virginiana.*

Pea, turkey-. See *Bikukulla canadensis.*

Pearl-plant. See *Onosmodium virginianum.*

Pencil-flower. See *Stylosanthes biflora.*

Pennyroyal, American. See *Hedeoma pulegioides.*

Penthorum sedoides L. **Virginia stonecrop family (Penthoraceae).**

Virginia stonecrop; ditch-stonecrop.

Native, perennial herb, about 1 foot in height, growing in ditches and swamps from New Brunswick to Minnesota, south to Florida and Texas.

Part used.—Herb (nonofficial.)

Pepper, water-. See *Polygonum hydropiper.*

Peppermint. See *Mentha piperita.*

Pepper-plant. See *Polygonum hydropiper.*

Peramium pubescens (Willd.) MacM. **Orchid family (Orchidaceae).**

Synonym.—Goodyera pubescens R. Br.

Downy rattlesnake-plantain; rattlesnake-weed; netleaf-plantain; scrofula-weed.

Native, perennial herb, 8 to 12 inches in height, occurring in rich woods from Newfoundland to Minnesota, south to Florida and Tennessee. Most common southward.

Part used.—Plant (nonofficial).

Peramium repens (L.) Salisb. **Orchid family (Orchidaceae).**

Synonym.—Goodyera repens R. Br.

White plantain; lesser rattlesnake-plantain; smaller netleaf-plantain; squirrel-ear.

A smaller plant than *P. pubescens*, but very similar to it and more common northward.

Part used.—Plant (nonofficial).

Persimmon. See *Diospyros virginiana.*

Phoradendron flavescens (Pursh) Nutt. **Mistletoe family (Loranthaceae).**

Synonym.—Viscum flavescens Pursh.

Mistletoe; American mistletoe.

Parasitic shrub, found on deciduous-leaved trees from New Jersey to Missouri, south to Florida and Texas.

Parts used.—Leaves and branches (nonofficial).

Phytolacca. See *Phytolacca decandra.*

Phytolacca americana L. Same as *Phytolacca decandra.*

Phytolacca decandra L.[a] **Pokeweed family (Phytolaccaceae).**

Synonym.—Phytolacca americana L.[a]

Phytolacca; poke; pokeweed; garget; scoke; inkberry.

Native, perennial herb, with large and branching stem, 6 to 10 feet high; in rich, moist soil, Maine to Minnesota, south to Florida and Texas.

Parts used.—Root collected in autumn (official); fruit (official in U. S. P. 1890); leaves (nonofficial).

Picea mariana (Mill.) B. S. P. **Pine family (Pinaceae).**

Synonym.—Abies nigra Desf.

Black spruce; spruce-gum tree.

Indigenous, evergreen tree, 40 to 80 feet in height, growing on elevated situations and in cold bogs from Canada south along the mountains to North Carolina, and to Minnesota.

Parts used.—Branches, and the essence obtained from the same (nonofficial).

Pilewort. See *Erechtites hieracifolia* and *Scrophularia marilandica.*

Pilotweed. See *Silphium laciniatum.*

Pimpernel. See *Pimpinella saxifraga.*

Pimpernel, red. See *Anagallis arvensis.*

Pimpernel, scarlet. See *Anagallis arvensis.*

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[a] *Phytolacca americana* L. by right of priority should be accepted, but *P. decandra* L. is used in conformity with the Pharmacopœia.

Pimpinella saxifraga L. **Parsley family (Apiaceae).**

Burnet-saxifrage; bennet; pimpernel.

Erect, perennial herb, 1 to 2 feet high, adventive from Europe, and found in waste places in eastern Pennsylvania, at several localities in the valley of the Delaware, and in Ohio.

Part used.—Root (nonofficial).

Pine, northern. See *Pinus strobus.*

Pine, prairie-. See *Lacinaria spicata.*

Pine, prince's-. See *Chimaphila umbellata*

Pine, Weymouth. See *Pinus strobus.*

Pine, white. See *Pinus strobus.*

Pink, rose-. See *Sabbatia angularis.*

Pinkroot. See *Spigelia marilandica.*

Pinkroot, Indian. See *Spigelia marilandica.*

Pinkroot, Maryland. See *Spigelia marilandica.*

Pinus strobus L. **Pine family (Pinaceae).**

White pine; northern pine; Weymouth pine.

Large, indigenous forest tree, sometimes 175 feet in height, growing in woods from Canada south to Georgia and Iowa.

Part used.—Bark (nonofficial).

Pipe-plant. See *Monotropa uniflora.*

Pipsissewa. See *Chimaphila umbellata.*

Pitcher-plant. See *Sarracenia purpurea.*

Plantago major L. **Plantain family (Plantaginaceae).**

Common plantain; dooryard-plantain; greater plantain.

Perennial herb, 1 to 3 feet high, naturalized from Europe; common in fields and waste places and along roadsides nearly throughout North America.

Parts used.—Root and leaves (nonofficial).

Plantain, common. See *Plantago major.*

Plantain, dooryard-. See *Plantago major.*

Plantain, downy rattlesnake-. See *Peramium pubescens.*

Plantain, greater. See *Plantago major.*

Plantain, lesser rattlesnake-. See *Peramium repens.*

Plantain, netleaf-. See *Peramium pubescens.*

Plantain, smaller netleaf-. See *Peramium repens.*

Plantain, white. See *Peramium repens.*

Pleurisy-root. See *Asclepias tuberosa.*

Podophyllum. See *Podophyllum peltatum.*

Podophyllum peltatum L. **Barberry family (Berberidaceae).**

Podophyllum; May-apple; wild mandrake; American mandrake; wild lemon.

Native, perennial herb, 1 to 1½ feet high, found in low, rich woods from Canada to Minnesota, south to Florida and Texas.

Part used.—Rhizome (official).

Poison-hemlock. See *Conium maculatum.*

Poison-ivy. See *Rhus radicans* and *R. toxicodendron.*

Poison-oak. See *Rhus radicans* and *R. toxicodendron.*

Poison-vine. See *Rhus radicans.*

Poke. See *Phytolacca decandra.*

Pokeweed. See *Phytolacca decandra.*

Polar-plant. See *Silphium laciniatum.*

Polecat-weed. See *Spathyema foetida.*

Polemonium reptans L. **Phlox family (Polemoniaceae).**

American Greek valerian; abscess-root; sweetroot; Jacob's-ladder.

Native, perennial herb, 12 to 20 inches high, growing in woods and damp ground from New York to Minnesota, south to Georgia and Missouri.

Part used.—Root (nonofficial).

Polygala nuttallii T. & G. **Milkwort family (Polygalaceae).**

Nuttall's-milkwort; ground-centaury.

Slender, erect, annual herb, 6 to 12 inches high, native in dry, sandy soil from Massachusetts to North Carolina, west to Alabama and Missouri.

Part used.—Herb (nonofficial).

Polygala senega L. **Milkwort family (Polygalaceae).**

Senega; Seneca snakeroot.

Native, perennial herb, 8 to 12 inches high, found in rocky woods and on hillsides from New Brunswick and western New England to Minnesota, south to North Carolina and Missouri.

Part used.—Root (official).

Polygonatum biflorum (Walt.) Ell. **Lily-of-the-valley family (Convallariaceae).**

Synonyms.—*Convallaria biflora* Walt.; *Salomonia biflora* (Walt.) Britton.

Hairy Solomon's-seal; smaller Solomon's-seal.

Native, perennial herb, 8 inches to 3 feet high, found in woods and thickets from Canada south to Florida and Michigan.

Part used.—Rhizome (nonofficial).

Polygonatum commutatum (Roem. & Schult.) Dietr. **Lily-of-the-valley family (Convallariaceae).**

Synonyms.—*Polygonatum giganteum* Dietr.; *Salomonia commutata* (Roem. & Schult.) Britton.

Giant Solomon's-seal; great Solomon's-seal; smooth Solomon's-seal.

Native, perennial herb, 1 to 8 feet high, occurring in moist woods and along streams from Canada to Georgia, west to Louisiana and Utah.

Part used.—Rhizome (nonofficial).

Polygonatum giganteum Dietr. Same as *Polygonatum commutatum.*

Polygonum hydropiper L. **Buckwheat family (Polygonaceae).**

Smartweed; water-pepper; biting knotweed; pepper-plant.

Smooth, annual plant, 8 inches to 2 feet high, naturalized from Europe; common in moist waste places almost throughout North America.

Part used.—Herb (nonofficial).

Polygonum punctatum Ell. **Buckwheat family (Polygonaceae).**

Dotted smartweed; water-smartweed.

Native, annual or perennial herb, found in swamps and other wet places throughout most of North America.

Part used.—Herb (nonofficial).

Polymnia uvedalia L. **Aster family (Asteraceae).**

Yellow bear's-foot; yellow leafcup; uvedalia.

Large, native, perennial plant, 3 to 6 feet high; in ravines and edges of woods from New York to Michigan, south to Florida and Texas.

Part used.—Root (nonofficial).

Polypodium filix-mas L. Same as *Dryopteris filix-mas.*

Polypodium marginale L. Same as *Dryopteris marginalis.*

Polypodium vulgare L. **Fern family (Polypodiaceae).**

Common polypody; fernroot; rock-brake; female-fern.

Native fern, 3 to 10 inches in height, with a perennial, creeping rhizome; on shady, rocky banks, in woods and mountains almost throughout North America.

Parts used.—Rhizome and tops (nonofficial).

Polypody, common. See *Polypodium vulgare.*

Polytrichum juniperinum Hedw. **Haircap-moss family (Polytrichaceae).**

Haircap-moss; robin's-rye.

Native moss, 4 to 7 inches in height, growing along margins of dry woods and exposed places, mostly on poor, sandy soil.

Part used.—Whole plant (nonofficial).

Pond-lily, large yellow. See *Nymphaea advena.*

Pond-lily, white. See *Castalia odorata.*

Poolroot. See *Eupatorium ageratoides, E. aromaticum,* and *Sanicula marilandica.*

Poolwort. See *Eupatorium ageratoides* and *E. aromaticum.*

Poplar, silver. See *Populus alba.*

Poplar, silverleaf-. See *Populus alba.*

Poplar, trembling. See *Populus tremuloides.*

Poplar, tulip-. See *Liriodendron tulipifera.*

Poplar, white. See *Populus alba* and *P. tremuloides.*

Poplar, yellow. See *Liriodendron tulipifera.*

Populus alba L. **Willow family (Salicaceae).**

White poplar; silverleaf-poplar; silver poplar; white-bark.

A large tree, sometimes 120 feet in height, naturalized in the United States; occurs along roadsides from New Brunswick to Virginia.

Part used.—Bark, collected in spring (nonofficial).

Populus balsamifera candicans A. Gray. Same as *Populus candicans.*

Populus candicans Ait. **Willow family (Salicaceae).**

Synonym.—*Populus balsamifera candicans* A. Gray.

Balm-of-Gilead.

A large tree, about 80 feet in height, mostly escaped from cultivation, New Brunswick to New Jersey, west to Minnesota.

Parts used.—Leafbuds and bark (nonofficial).

Populus tremuloides Michx. **Willow family (Salicaceae).**

Quaking aspen; American aspen; white poplar; trembling poplar; quiverleaf.

A slender, indigenous tree, growing in dry or moist soil from lower Canada south to Kentucky and in the Rocky Mountains to Lower California.

Part used.—Bark, collected in spring (nonofficial).

Porteranthus trifoliatus (L.) Britton. **Rose family (Rosaceae).**

Synonym.—*Gillenia trifoliata* Moench.

Indian-physic; Bowman's-root; false ipecac; western dropwort.

Native, perennial herb, 2 to 3 feet high, found in moist, shady places in rich woods from New York to Michigan, south to Georgia and Missouri; more common in the Atlantic States than in the Western States.

Part used.—Root (nonofficial).

Potato, hog-. See *Ipomoea pandurata.*

Potato, wild. See *Ipomoea pandurata.*

Potentilla canadensis L. **Rose family (Rosaceae).**

Fivefinger; cinquefoil.

A small, annual or biennial plant, with creeping stems, growing in dry soil from Quebec to Georgia, west to Minnesota and the Indian Territory.

Part used.—Plant (nonofficial).

Prairie-pine. See *Lacinaria spicata.*

Prenanthes alba L. Same as *Nabalus albus.*

Prenanthes serpentaria Pursh. Same as *Nabalus serpentarius.*

Prickly ash, northern. See *Xanthoxylum americanum.*

Prickly ash, southern. See *Fagara clava-herculis.*

Prideweed. See *Erigeron canadensis.*

Prim. See *Ligustrum vulgare.*

Primrose, evening-. See *Oenothera biennis.*

Primrose, tree-. See *Oenothera biennis.*

Primwort. See *Ligustrum vulgare.*

Prince's-pine. See *Chimaphila umbellata.*

Prinos verticillatus L. Same as *Ilex verticillata.*

Privet. See *Ligustrum vulgare.*

Prunella vulgaris L. **Mint family (Menthaceae).**

Self-heal; heal-all; brownwort; sicklewort; blue-curls.

Perennial plant, 2 inches to 2 feet high, naturalized from Europe, and found in fields, woods, and waste places throughout nearly the whole of North America.

Part used.—Herb (nonofficial).

Prunus serotina Ehrh. **Plum family (Amygdalaceae).**

Synonym.—*Prunus virginiana* Mill., not of Linnaeus.

Prunus virginiana; wild cherry; rum-cherry.

A large, indigenous tree, 50 to 80 feet high, growing in woods or open places from Ontario to Florida, west to Texas and Dakota. Most abundant in the Southwestern States.

Part used.—Bark, which should be collected in autumn and carefully dried and preserved (official).

Prunus virginiana. See *Prunus serotina.*

Prunus virginiana Mill., not L. Same as *Prunus serotina.*

Psoralea. See *Psoralea pedunculata.*

Psoralea melilotoides Michx. Same as *Psoralea pedunculata.*

Psoralea pedunculata (Mill.) Vail. **Pea family (Fabaceae).**

Synonym.—*Psoralea melilotoides* Michx.

Psoralea; Samson's-snakeroot; Congo-root.

Slender, herbaceous perennial, 1 to 2½ feet high, native in dry soil in open woods from Ohio and Kentucky southward.

Parts used.—Root and leaves (nonofficial).

Ptelea trifoliata L. **Rue family (Rutaceae).**

Wafer-ash; wingseed; hop-tree; shrubby trefoil.

Native shrub, 6 to 8 feet high; in shady woods from New York to Florida, west to Minnesota and Texas; grows more abundantly west of the Alleghenies.

Parts used.—Bark of root, fruit, and leaves (nonofficial).

Pterocaulon undulatum (Walt.) Mohr. **Aster family (Asteraceae).**

Synonym.—*Gnaphalium undulatum* Walt.

Indian blackroot.

Native, perennial herb, growing in sandy pine lands from North Carolina to Florida and Mississippi.

Part used.—Root (nonofficial).

Puccoon, red. See *Sanguinaria canadensis.*

Puccoon, yellow. See *Hydrastis canadensis.*

Pulsatilla, American. See *Pulsatilla hirsutissima.*

Pulsatilla hirsutissima (Pursh) Britton. **Crowfoot family (Ranunculaceae).**

Synonym.—*Anemone patens* var. *nuttalliana* A. Gray.

American pasqueflower; American pulsatilla.

Native, perennial herb, 6 to 16 inches high, found in the prairie regions of Illinois, west to the Rocky Mountains and the Northwest.

Part used.—Flowering herb (nonofficial).

Purging-root. See *Euphorbia corollata.*

Purslane, black. See *Euphorbia nutans.*

Purslane, milk-. See *Euphorbia nutans.*

Pussy-willow. See *Salix nigra.*

Putty-root. See *Aplectrum spicatum.*

Pycnanthemum montanum Michx. Same as *Koellia montana.*

Pycnanthemum pilosum Nutt. Same as *Koellia pilosa.*

Pyramid-flower. See *Frasera carolinensis.*

Pyrethrum parthenium Smith. Same as *Chrysanthemum parthenium.*

Pyrus americana DC. Same as *Sorbus americana.*

Quack-grass. See *Agropyron repens.*

Queen-Anne's-lace. See *Daucus carota.*

Queen-of-the-meadow. See *Eupatorium purpureum.*

Queen's-delight. See *Stillingia sylvatica.*

Queensland asthma-weed. See *Euphorbia pilulifera.*

Queen's-root. See *Stillingia sylvatica.*

Quercus. See *Quercus alba.*

Quercus alba L. **Beech family (Fagaceae).**

Quercus; white oak; stone-oak.

Large, indigenous forest tree, 50 to 100 feet in height, in woods from Maine to Minnesota, south to Florida and Texas. More abundant in the Middle States.

Part used.—Bark, "collected from trunks or branches 10 to 25 years of age, and deprived of the periderm" (official).

Quercus rubra L. **Beech family (Fagaceae).**

Red oak; champion-oak; Spanish oak.

Large, wide-spreading, indigenous forest tree, about 70 feet in height, from Nova Scotia to Minnesota, south to Florida and Texas. More common in the Northern States and in Canada.

Part used.—Bark (nonofficial).

Quinine-flower. See *Sabbatia elliottii.*

Quinine-herb. See *Sabbatia elliottii.*

Quinine-plant. See *Sabbatia elliottii.*

Quiverleaf. See *Populus tremuloides.*

Ragged-cup. See *Silphium perfoliatum.*

Ragweed. See *Ambrosia artemisiaefolia.*

Ragwort, golden. See *Senecio aureus.*

Raspberry, black. See *Rubus occidentalis.*

Raspberry, ground-. See *Hydrastis canadensis.*

Raspberry, wild red. See *Rubus strigosus.*

Rattle-root. See *Cimicifuga racemosa.*

Rattlesnake-herb. See *Actaea alba* and *A. rubra.*

Rattlesnake-master. See *Eryngium yuccifolium*, *Liatris scariosa*, *L. spicata*, and *L. squarrosa*.

Rattlesnake-plantain, downy. See *Peramium pubescens*.

Rattlesnake-plantain, lesser. See *Peramium repens*.

Rattlesnake-root. See *Nabalus albus* and *N. serpentarius*.

Rattlesnake-violet. See *Erythronium americanum*.

Rattlesnake-weed. See *Eryngium yuccifolium*, *Hieracium venosum*, and *Peramium pubescens*.

Redbud. See *Cercis canadensis*.

Redroot. See *Ceanothus americanus*.

Rhamnus cathartica L. **Buckthorn family (Rhamnaceae).**

Buckthorn; hart's-thorn; waythorn.

A shrub 6 to 15 feet high, introduced from Europe; escaped from hedges and growing in dry soil in the New England and Middle States.

Part used.—Berries (nonofficial).

Rhamnus purshiana. See *Rhamnus purshiana* DC.

Rhamnus purshiana DC. **Buckthorn family (Rhamnaceae).**

Rhamnus purshiana; cascara sagrada; chittem-bark; sacred-bark; bearberry-tree.

Small, indigenous tree, 15 to 20 feet in height, found on the sides and bottoms of canyons, Rocky Mountains west to the Pacific Ocean, and extending north into British America.

Part used.—Bark, collected at least one year before being used (official).

Rheumatism-root. See *Dioscorea villosa* and *Jeffersonia diphylla*.

Rheumatism-weed. See *Chimaphila umbellata*.

Rhododendron maximum L. **Heath family (Ericaceae).**

Great laurel; rose-bay; deer-laurel; rose-laurel.

Tall, native, evergreen shrub or small tree, found in low woods and along streams from Canada to Georgia.

Part used.—Leaves (nonofficial).

Rhus aromatica Ait. **Sumac family (Anacardiaceae).**

Fragrant sumac; sweet-scented sumac.

Indigenous shrub, 2 to 6 feet high, growing in woods and rocky situations, Canada to Florida, especially along the mountains, west to Minnesota and Arkansas.

Part used.—Bark of root (nonofficial).

Rhus glabra. See *Rhus glabra* L.

Rhus glabra L. **Sumac family (Anacardiaceae).**

Rhus glabra; smooth sumac; scarlet sumac.

Indigenous, branching shrub, from 4 to 12 feet high; in dry soil, thickets, and waste grounds nearly throughout the United States and Canada.

Parts used.—Fruit (official); bark and leaves (nonofficial).

Rhus radicans L.[a] **Sumac family (Anacardiaceae).**

Rhus toxicodendron (pharmacopœial name, 1890); poison-ivy; poison-oak; poison-vine.

Native, woody vine, clinging to trees and fence rows; Canada to Florida, west to Nebraska and Arkansas. Very poisonous to the touch.

Part used.—Fresh leaves (official in U. S. P. 1890).

Rhus toxicodendron. See *Rhus radicans*.

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[a] *Rhus radicans* L. was formerly believed to be a variety of *Rhus toxicodendron* L., but the two are now regarded as distinct species, and the leaves from both have been used under the pharmacopœial name (U. S. P. 1890) Rhus toxicodendron.

Rhus toxicodendron L. **Sumac family (Anacardiaceae).**

Poison-ivy; poison-oak.

Low, erect, and finely pubescent plant, more shrubby than *Rhus radicans*, and found in dry soil in more southern localities from Virginia to Georgia. Very poisonous to the touch.

Part used.—Fresh leaves, collected with those of *Rhus radicans*.

Richweed. See *Collinsonia canadensis* and *Eupatorium ageratoides*.

Robinia pseudacacia L. **Pea family (Fabaceae).**

Locust-tree; black locust; yellow locust; false acacia.

A large, indigenous tree, sometimes 80 feet in height, growing in woods from Pennsylvania south along the western slope of the Allegheny Mountains to Georgia, west to the Indian Territory. Most abundant in the Middle and Eastern States.

Part used.—Bark of root (nonofficial).

Robin's-rye. See *Polytrichum juniperinum*.

Rock-brake. See *Polypodium vulgare*.

Rock-rose, Canadian. See *Helianthemum canadense*.

Rope-bark. See *Dirca palustris*.

Rose, Canadian rock-. See *Helianthemum canadense*.

Rose-bay. See *Rhododendron maximum*.

Rose-laurel. See *Rhododendron maximum*.

Rosemary, marsh-. See *Limonium carolinianum*.

Rose-pink. See *Sabbatia angularis*.

Rose-willow. See *Cornus amomum*.

Rosinweed. See *Silphium laciniatum*.

Roundwood. See *Sorbus americana*.

Rubus. See *Rubus cuneifolius*, *R. nigrobaccus*, *R. procumbens*, *R. trivialis*, and *R. villosus*.

Rubus canadensis T. & G., not L. Same as *Rubus procumbens*.

Rubus cuneifolius Pursh. **Rose family (Rosaceae).**

Rubus; sand-blackberry; knee-high blackberry.

Shrubby plant, 1 to 3 feet high; in sandy soil from Connecticut to Florida, west to Missouri and Louisiana.

Part used.—Bark of rhizome (official).

Rubus idaeus var. *americanus* Torr. Same as *Rubus occidentalis*.

Rubus nigrobaccus Bailey. **Rose family (Rosaceae).**

Synonym.—*Rubus villosus* A. Gray, not Ait.

Rubus; high-bush blackberry.

Slender shrub, 3 to 7 feet high, growing in dry fields and along roadsides, New England States to Florida, and west to Arkansas.

Part used.—Bark of rhizome (official).

Rubus occidentalis L. **Rose family (Rosaceae).**

Synonym.—*Rubus idaeus* var. *americanus* Torr.

Black raspberry; thimbleberry; blackcap.

A straggling shrub, growing along the borders of woods and in rocky thickets from Canada south to Georgia and Missouri.

Parts used.—Fruit and leaves (nonofficial).

Rubus procumbens Muhl. **Rose family (Rosaceae).**

Synonym.—*Rubus canadensis* T. & G., not L.

Rubus; low running blackberry; dewberry.

Shrubby, trailing plant, found in dry soil from Newfoundland to Lake Superior, south to Virginia and the Indian Territory.

Part used.—Bark of root (official in U. S. P. 1890).

Rubus strigosus Michx. **Rose family (Rosaceae).**

Wild red raspberry.

Shrubby plant, found in dry or rocky situations from Canada to North Carolina and New Mexico.

Parts used.—Fruit and leaves (nonofficial).

Rubus trivialis Michx. **Rose family (Rosaceae).**

Rubus; southern dewberry; low-bush blackberry.

Shrubby, procumbent plant, found in sandy soils, Virginia to Florida, west to Missouri and Texas.

Part used.—Bark of root (official in U. S. P. 1890).

Rubus villosus A. Gray, not Ait. Same as *Rubus nigrobaccus.*

Rubus villosus Ait. **Rose family (Rosaceae).**

Rubus; one-flowered dewberry.

Trailing plant, with slender branches, growing in sandy or dry soil near the coast from Maine to South Carolina.

Part used.—Bark of rhizome (official)

Rudbeckia laciniata L. **Aster family (Asteraceae).**

Thimbleweed; tall coneflower.

Much-branched, native perennial, 3 to 12 feet high; in moist thickets, Canada and Montana, south to Florida and New Mexico.

Part used.—Herb (nonofficial).

Rum-cherry. See *Prunus serotina.*

Rumex. See *Rumex crispus.*

Rumex acetosella L. **Buckwheat family (Polygonaceae).**

Sheep-sorrel; field-sorrel; sour-grass; common sorrel.

Annual or perennial herb, abundant in dry fields, pastures, and waste ground throughout the United States.

Part used.—Leaves (nonofficial).

Rumex crispus L. **Buckwheat family (Polygonaceae).**

Rumex; yellow dock; curled dock; narrow dock; sour dock.

A weed introduced from Europe, and common in cultivated and waste ground throughout the United States. Perennial plant, 2 to 4 feet high.

Part used.—Root of this and some other species of Rumex (official in U. S. P. 1890).

Rumex obtusifolius L. **Buckwheat family (Polygonaceae).**

Bitter dock; blunt-leaved dock; broad-leaved dock.

A perennial weed, 2 to 4 feet high, naturalized from Europe, and found in waste places from New England to Florida, west to Texas and Oregon.

Part used.—Root, collected with that of *Rumex crispus.*

Sabal. See *Serenoa serrulata.*

Sabbatia angularis (L.) Pursh. **Gentian family (Gentianaceae).**

American centaury; rose-pink; bitterbloom; bitter clover.

Native, biennial plant, 1 to 2 feet high, growing in damp, rich soil, in meadows and among high grass, from New York to Michigan, south to Florida and the Indian Territory.

Part used.—Herb (nonofficial).

Sabbatia elliottii Steud. **Gentian family (Gentianaceae).**

Synonym.—Sabbatia paniculata Ell.

Quinine-flower; quinine-plant; quinine-herb; Elliott's-sabbatia.

An erect, native herb, about one foot in height, growing in pine barrens from North Carolina to Florida.

Part used.—Herb (nonofficial).

Sabbatia, Elliott's-. See *Sabbatia elliottii.*

Sabbatia paniculata Ell. Same as *Sabbatia elliottii.*

Sabina. See *Juniperus sabina.*

Sacred-bark. See *Rhamnus purshiana.*

Sage, Indian. See *Eupatorium perfoliatum.*

Saint-Benedict's thistle. See *Cnicus benedictus.*

Saint-John's wort, common. See *Hypericum perforatum.*

Salix alba L. **Willow family (Salicaceae).**

White willow; European willow.

A large tree, sometimes 90 feet in height, introduced from Europe; occurs in moist soil along streams from Pennsylvania northward to New Brunswick and Ontario, sparingly escaped from cultivation.

Part used.—Bark (nonofficial).

Salix nigra Marsh. **Willow family (Salicaceae).**

Black willow; pussy-willow; swamp-willow.

Tall, indigenous tree, growing on banks of rivers from Canada to Florida and California.

Parts used.—Bark, and fresh aments gathered early in May (nonofficial).

Salomonia biflora (Walt.) Britton. Same as *Polygonatum biflorum.*

Salomonia commutata (Roem. & Schult.) Dietr. Same as *Polygonatum commutatum.*

Salt-rheum weed. See *Chelone glabra.*

Sambucus. See *Sambucus canadensis.*

Sambucus canadensis L. **Honeysuckle family (Caprifoliaceae).**

Sambucus; elder; American elder; sweet elder.

Indigenous shrub, 6 to 10 feet high, growing in low, damp ground from Canada to Florida and Arizona.

Parts used.—Flowers (official in U. S. P. 1890); bark and berries (nonofficial).

Sampson-root. See *Brauneria angustifolia.*

Sampson's-snakeroot. See *Gentiana villosa.*

Samson's-snakeroot. See *Psoralea pedunculata.*

Sand-blackberry. See *Rubus cuneifolius.*

Sandbrier. See *Solanum carolinense.*

Sanguinaria. See *Sanguinaria canadensis.*

Sanguinaria canadensis L. **Poppy family (Papaveraceae).**

Sanguinaria; bloodroot; red puccoon; Indian-paint; tetterwort.

Native, perennial herb, about 6 inches high, found in rich, open woods from Nova Scotia to Nebraska, south to Florida and Arkansas.

Part used.—Rhizome, "collected after the death of the foliage" (official).

Sanicle, American. See *Heuchera americana* and *Sanicula marilandica.*

Sanicle, black. See *Sanicula marilandica.*

Sanicle, Indian. See *Eupatorium ageratoides.*

Sanicle, white. See *Eupatorium ageratoides.*

Sanicula marilandica L. **Parsley family (Apiaceae).**

Black sanicle; black snakeroot; American sanicle; poolroot.

Native, perennial herb, 1 to 3 feet high; in rich woods, Canada to Georgia.

Part used.—Root (nonofficial).

Saponaria officinalis L. **Pink family (Silenaceae).**

Soapwort; soaproot; bouncing-Bet; fuller's-herb.

Stout, perennial herb, 1 to 2 feet high, naturalized from Europe and found along roadsides and waste places; common almost everywhere.

Parts used.—Root and herb (nonofficial).

Sarothamnus scoparius Wimm. Same as *Cytisus scoparius.*

Sarracenia flava L. **Pitcher-plant family (Sarraceniaceae).**

Trumpetleaf; trumpets; Eve's-cup; watercup; yellow-flowered watercup.

Curious, indigenous perennial, about 1 to 3 feet high, found in low, wet pine barrens in the southeastern United States.

Parts used.—Root and sometimes the leaves (nonofficial).

Sarracenia purpurea L. **Pitcher-plant family (Sarraceniaceae).**

Pitcher-plant; flytrap; sidesaddle-flower; watercup; smallpox-plant.

Indigenous perennial, 1 to 2 feet high, growing in wet, boggy places and marshes, from Canada to Minnesota and Florida.

Parts used.—Root and sometimes the leaves (nonofficial).

Sarsaparilla, American. See *Aralia nudicaulis.*

Sarsaparilla, bristly. See *Aralia hispida.*

Sarsaparilla, false. See *Aralia nudicaulis.*

Sarsaparilla, Texas. See *Menispermum canadense.*

Sarsaparilla, Virginian. See *Aralia nudicaulis.*

Sarsaparilla, wild. See *Aralia nudicaulis.*

Sassafras. See *Sassafras variifolium.*

Sassafras officinale Nees & Eberm. Same as *Sassafras variifolium.*

Sassafras sassafras (L.) Karst. Same as *Sassafras variifolium.*

Sassafras, swamp-. See *Magnolia virginiana.*

Sassafras variifolium (Salisb.) O. Kuntze.[a] **Laurel family (Lauraceae).**

Synonyms.—*Sassafras officinale* Nees & Eberm.; *Sassafras sassafras* (L.) Karst.[a]

Sassafras; ague-tree.

Native tree, sometimes reaching a height of 125 feet; in rich woods, Massachusetts to Ontario and Michigan, south to Florida and Texas.

Parts used.—Bark of root, collected in early spring or autumn and deprived of the periderm (official); pith (official); and the oil of sassafras distilled from the root, especially the root bark (official).

Satureia hortensis L. **Mint family (Menthaceae).**

Summer-savory.

Hairy, aromatic, annual herb, adventive from Europe and occurring in waste places from Canada to Pennsylvania and Nevada.

Part used.—Herb (nonofficial).

Savin. See *Juniperus sabina.*

Savin, red. See *Juniperus virginiana.*

Savory, summer-. See *Satureia hortensis.*

Saw-palmetto. See *Serenoa serrulata.*

Saxifrage, burnet-. See *Pimpinella saxifraga.*

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[a] Although the combination *Sassafras sassafras* (L.) Karst. should be accepted by strict right of priority, the usage of the Pharmacopœia is followed.

Scabious, sweet. See *Erigeron philadelphicus.*

Scabish, meadow-. See *Aster puniceus.*

Scabwort. See *Inula helenium.*

Scarletberry. See *Solanum dulcamara.*

Scoke. See *Phytolacca decandra.*

Scoparius. See *Cytisus scoparius.*

Scouring-rush, common. See *Equisetum hyemale.*

Scrofula-plant. See *Scrophularia marilandica.*

Scrofula-weed. See *Peramium pubescens.*

Scrophularia marilandica L. **Figwort family (Scrophulariaceae).**

Synonym.—*Scrophularia nodosa* var. *marilandica* A. Gray.

Maryland figwort; scrofula-plant; carpenter's-square; heal-all; bee-plant; pile-wort.

Smooth, native perennial, 3 to 5 feet high; moist, shady ground in woods and thickets, New York to North Carolina and Kansas.

Parts used.—Herb and root (nonofficial).

Scrophularia nodosa var. *marilandica* A. Gray. Same as *Scrophularia marilandica.*

Scutellaria. See *Scutellaria lateriflora.*

Scutellaria hyssopifolia L. Same as *Scutellaria integrifolia.*

Scutellaria integrifolia L. **Mint family (Menthaceae).**

Synonym.—*Scutellaria hyssopifolia* L.

Larger skullcap; hyssop-skullcap.

Native, perennial herb, 6 inches to 2 feet high, found in fields and woods from Connecticut south to Florida and Texas.

Part used.—Herb (nonofficial).

Scutellaria lateriflora L. **Mint family (Menthaceae).**

Scutellaria; skullcap; madweed; hoodwort.

Smooth, branching perennial, 1 to 2 feet high, native in damp places along banks of streams from Canada south to Florida, New Mexico, and Washington.

Part used.—Plant (official).

Sea-lavender. See *Limonium carolinianum.*

Self-heal. See *Prunella vulgaris.*

Senecio aureus L. **Aster family (Asteraceae).**

Liferoot; swamp squaw-weed; golden ragwort; cocash-weed; coughweed.

Indigenous, perennial herb, 1 to 2½ feet high, growing in swamps and wet meadows, Newfoundland to Ontario, south to Florida, Missouri, and Texas.

Parts used.—Root and herb (nonofficial).

Senega. See *Polygala senega.*

Senna, American. See *Cassia marilandica.*

Senna, wild. See *Cassia marilandica.*

Serenoa serrulata (Roem. & Schult.) Hook. f. **Palm family (Phoenicaceae).**

Sabal; saw-palmetto.

A palm, 3 to 7 feet in height, found in sandy soil from North Carolina and Arkansas to Florida and Texas.

Part used.—Partially dried ripe fruit (official).

Serpentaria. See *Aristolochia reticulata* and *A. serpentaria*

Serpentaria, Texas. See *Aristolochia reticulata.*

Serpentaria, Virginia. See *Aristolochia serpentaria.*

Service-tree, American. See *Sorbus americana.*

Seven-barks. See *Hydrangea arborescens.*

Shagbark. See *Hicoria ovata.*

Shamrock. See *Oxalis acetosella.*

Shamrock, water-. See *Menyanthes trifoliata.*

Shave-grass. See *Equisetum hyemale.*

Sheepberry. See *Viburnum lentago.*

Sheep-laurel. See *Kalmia angustifolia* and *K. latifolia.*

Sheep-sorrel. See *Rumex acetosella.*

Shellbark-hickory. See *Hicoria ovata.*

Shellflower. See *Chelone glabra.*

Shepherd's-purse. See *Bursa bursa-pastoris.*

Shepherd's-weatherglass. See *Anagallis arvensis.*

Shield-fern, marginal-fruited. See *Dryopteris marginalis.*

Shrub, sweet-scented. See *Butneria florida.*

Shrub yellowroot. See *Xanthorrhiza apiifolia.*

Sicklewort. See *Prunella vulgaris.*

Sidesaddle-flower. See *Sarracenia purpurea.*

Silkweed. See *Asclepias syriaca.*

Silkweed, rose-colored. See *Asclepias incarnata.*

Silkweed, swamp-. See *Asclepias incarnata.*

Silphium laciniatum L. **Aster family (Asteraceae).**

Rosinweed; compass-plant; pilotweed; polar-plant.

Coarse, native perennial, 3 to 12 feet high, growing on prairies from Ohio to Alabama, west to Texas and South Dakota.

Part used.—Herb (nonofficial).

Silphium perfoliatum L. **Aster family (Asteraceae).**

Cup-plant; Indian-cup; ragged-cup.

Stout, perennial herb, 4 to 8 feet high, native in moist soil and low ground from Ontario and the eastern United States west to Louisiana and Nebraska.

Part used.—Root (nonofficial).

Silverleaf. See *Impatiens biflora, Spiraea tomentosa,* and *Stillingia sylvatica.*

Silverleaf-poplar. See *Populus alba.*

Simpler's-joy. See *Verbena hastata.*

Sinapis alba. See *Sinapis alba* L.

Sinapis alba L. **Mustard family (Brassicaceae).**

Sinapis alba; white mustard; yellow mustard.

Annual herb, about 2 feet in height, naturalized from Europe, and found in fields and waste places, but not so widely distributed as the black mustard.

Part used.—Seed (official).

Sinapis nigra. See *Brassica nigra.*

Sinapis nigra L. Same as *Brassica nigra.*

Skullcap. See *Scutellaria lateriflora.*

Skullcap, hyssop-. See *Scutellaria integrifolia.*

Skullcap, larger. See *Scutellaria integrifolia.*

Skunk-cabbage. See *Spathyema foetida.*

Skunkweed. See *Spathyema foetida.*

Sloe. See *Viburnum prunifolium.*

Smallpox-plant. See *Sarracenia purpurea.*

Smartweed. See *Polygonum hydropiper.*

Smartweed, dotted. See *Polygonum punctatum.*

Smartweed, water-. See *Polygonum punctatum.*

Smilacina racemosa Desf. Same as *Vagnera racemosa.*

Smilax herbacea L. **Smilax family (Smilacaceae).**

Carrion-flower; American Jacob's-ladder.

Native, herbaceous perennial, occurring in woods and thickets in Canada and the eastern United States.

Part used.—Herb (nonofficial).

Smilax pseudo-china L. **Smilax family (Smilacaceae).**

Bamboo-brier; long-stalked greenbrier; American China-root; false China-root; bullbrier.

Perennial vine, native, growing in dry or sandy thickets, Maryland to Florida, west to Texas and Nebraska.

Part used.—Rhizome (nonofficial).

Snake-gentian. See *Nabalus serpentarius.*

Snakehead. See *Chelone glabra.*

Snakeleaf, yellow. See *Erythronium americanum.*

Snake-lily. See *Iris versicolor.*

Snakemilk. See *Euphorbia corollata.*

Snakeroot, black. See *Cimicifuga racemosa* and *Sanicula marilandica.*

Snakeroot, button-. See *Eryngium yuccifolium.*

Snakeroot, Canada. See *Asarum canadense.*

Snakeroot, corn-. See *Eryngium yuccifolium* and *Lacinaria spicata.*

Snakeroot, dense button-. See *Lacinaria spicata.*

Snakeroot, large button-. See *Lacinaria scariosa.*

Snakeroot, Red River. See *Aristolochia reticulata.*

Snakeroot, Sampson's- See *Gentiana villosa.*

Snakeroot, Samson's-. See *Psoralea pedunculata.*

Snakeroot, Seneca. See *Polygala senega.*

Snakeroot, smaller white. See *Eupatorium aromaticum.*

Snakeroot, Texas. See *Aristolochia reticulata.*

Snakeroot, Virginia. See *Aristolochia serpentaria.*

Snakeroot, white. See *Eupatorium ageratoides.*

Snake-violet. See *Viola pedata.*

Snakeweed. See *Euphorbia pilulifera.*

Snapweed. See *Impatiens aurea* and *I. biflora.*

Sneezeweed. See *Helenium autumnale.*

Sneezewort. See *Helenium autumnale.*

Snowdrop, yellow. See *Erythronium americanum.*

Soaproot. See *Saponaria officinalis.*

Soapwort. See *Saponaria officinalis.*

Soapwort-gentian. See *Gentiana saponaria.*

Solanum carolinense L. **Potato family (Solanaceae).**

Horse-nettle; bull-nettle; sandbrier.

Rough-hairy, native, perennial herb, common in dry fields and on sandy or gravelly banks from the eastern United States west to Texas and Nebraska.

Parts used.—Root, leaves, and berries (nonofficial).

Solanum dulcamara L. **Potato family (Solanaceae).**

Dulcamara; bittersweet; woody nightshade; violet-bloom; scarletberry.

Climbing, shrubby perennial, naturalized from Europe; found in low, damp grounds and moist banks, New Brunswick to Minnesota, south to New Jersey and Kansas.

Part used.—Young branches (official in U. S. P. 1890).

Solidago odora Ait. **Aster family (Asteraceae).**

Sweet goldenrod; fragrant-leaved goldenrod; anise-scented goldenrod.

Slender, perennial herb, 2 to 3 feet high, native; in dry soil from Maine to Texas.

Parts used.—Leaves and tops (nonofficial).

Solomon's-seal, false. See *Vagnera racemosa.*

Solomon's-seal, giant. See *Polygonatum commutatum.*

Solomon's-seal, great. See *Polygonatum commutatum.*

Solomon's-seal, hairy. See *Polygonatum biflorum.*

Solomon's-seal, small. See *Vagnera racemosa.*

Solomon's-seal, smaller. See *Polygonatum biflorum.*

Solomon's-seal, smooth. See *Polygonatum commutatum.*

Sorbus americana Marsh. **Apple family (Malaceae).**

Synonym.—*Pyrus americana* DC.

American mountain-ash; roundwood; dogberry; mountain-sumac; American service-tree.

Indigenous tree or tall shrub, growing in low woods or moist ground from Newfoundland south along the mountains to North Carolina, and to Michigan.

Parts used.—Bark and berries (nonofficial).

Sorrel, common. See *Rumex acetosella.*

Sorrel, field-. See *Rumex acetosella.*

Sorrel, sheep-. See *Rumex acetosella.*

Sorrel, white wood-. See *Oxalis acetosella.*

Sorrel-tree. See *Oxydendrum arboreum.*

Sour-grass. See *Rumex acetosella.*

Sourwood. See *Oxydendrum arboreum.*

Southernwood. See *Artemisia abrotanum.*

Spathyema foetida (L.) Raf. **Arum family (Araceae).**

Synonyms.—*Dracontium foetidum* L.; *Symplocarpus foetidus* Nutt.

Skunk-cabbage; skunkweed; polecat-weed; swamp-cabbage.

Indigenous, perennial herb, about 1 to 2 feet high, found in swamps and wet soil from Canada south to Florida, Iowa, and Minnesota. Appears very early in spring.

Parts used.—Rhizome and roots (nonofficial).

Spatter-dock. See *Nymphaea advena.*

Spearmint. See *Mentha spicata.*

Speedwell, common. See *Veronica officinalis.*

Speedwell, tall. See *Veronica virginica.*

Spicebush. See *Benzoin benzoin.*

Spicewood. See *Benzoin benzoin.*

Spigelia. See *Spigelia marilandica.*

Spigelia marilandica L. **Logania family (Loganiaceae).**

Spigelia; pinkroot; Maryland pinkroot; Indian pinkroot; worm-grass.

Erect, native, perennial herb, 6 inches to 1½ feet high, found in rich woods, New Jersey to Florida, west to Texas and Wisconsin. Occurs principally in the Southern States.

Parts used.—Rhizome and roots (official).

Spignet. See *Aralia racemosa.*

Spikenard. See *Aralia racemosa.*

Spikenard, American. See *Aralia racemosa.*

Spikenard, false. See *Vagnera racemosa.*

Spikenard, small. See *Aralia nudicaulis.*

Spikenard, wild. See *Vagnera racemosa.*

Spindle-tree. See *Euonymus atropurpureus.*

Spiraea. See *Spiraea tomentosa.*

Spiraea tomentosa L. **Rose family (Rosaceae).**

Spiraea; hardhack; steeplebush; pink meadowsweet; silverleaf.

Native shrub, occurring in low grounds and moist meadows from Nova Scotia south to Georgia, west to Kansas and Manitoba.

Parts used.—Leaves and root (nonofficial).

Spleenwortbush. See *Comptonia peregrina.*

Spruce, black. See *Picea mariana.*

Spruce, hemlock-. See *Tsuga canadensis.*

Spruce, weeping. See *Tsuga canadensis.*

Spruce-gum tree. See *Picea mariana.*

Spurge, flowering. See *Euphorbia corollata.*

Spurge, ipecac-. See *Euphorbia ipecacuanhae.*

Spurge, large spotted. See *Euphorbia nutans.*

Spurge, pill-bearing. See *Euphorbia pilulifera.*

Spurge-laurel. See *Daphne mezereum.*

Spurge-olive. See *Daphne mezereum.*

Squawberry. See *Mitchella repens.*

Squawbush. See *Viburnum opulus.*

Squawflower. See *Trillium erectum.*

Squawmint. See *Hedeoma pulegioides.*

Squawroot. See *Caulophyllum thalictroides* and *Cimicifuga racemosa.*

Squaw-vine. See *Mitchella repens.*

Squaw-weed. See *Eupatorium ageratoides.*

Squaw-weed, swamp. See *Senecio aureus.*

Squirrel-corn. See *Bikukulla canadensis.*

Squirrel-ear. See *Peramium repens.*

Staff-tree. See *Celastrus scandens.*

Stagbush. See *Viburnum prunifolium.*

Staggerweed. See *Bikukulla canadensis.*

Stag's-horn. See *Lycopodium clavatum.*

Stammerwort. See *Ambrosia artemisiaefolia.*

Star-grass. See *Aletris farinosa.*

Starwort. See *Chamaelirium luteum.*

Starwort, drooping. See *Chamaelirium luteum.*

Statice caroliniana Walt. Same as *Limonium carolinianum.*

Steeplebush. See *Spiraea tomentosa.*

Stellaria media Cyr. Same as *Alsine media.*

Stillingia. See *Stillingia sylvatica.*

Stillingia sylvatica L. **Spurge family (Euphorbiaceae).**

Stillingia; queen's-root; queen's-delight; silverleaf.

Native, herbaceous perennial, 1 to 3 feet in height, occurring in dry, sandy soil, and pine barrens from Maryland to Florida, west to Kansas and Texas.

Part used.—Root (official).

Stonecrop, ditch-. See *Penthorum sedoides.*

Stonecrop, Virginia. See *Penthorum sedoides.*

Stonemint. See *Cunila origanoides.*

Stone-oak. See *Quercus alba.*

Stoneroot. See *Collinsonia canadensis.*

Stramonium. See *Datura stramonium.*

Strawberry, scarlet. See *Fragaria virginiana.*

Strawberry, Virginia. See *Fragaria virginiana.*

Strawberry-shrub, hairy. See *Butneria florida.*

Stylosanthes biflora (L.) B. S. P. **Pea family (Fabaceae).**

Synonym.—*Stylosanthes elatior* Sw.

Pencil-flower; afterbirth-weed.

Wiry, perennial herb, 6 inches to 2 feet in height, native; occurring in dry soil from New York to Florida, west to the Indian Territory.

Part used.—Herb (nonofficial).

Stylosanthes elatior Sw. Same as *Stylosanthes biflora.*

Succory. See *Cichorium intybus.*

Sumac, fragrant. See *Rhus aromatica.*

Sumac, mountain-. See *Sorbus americana.*

Sumac, scarlet. See *Rhus glabra.*

Sumac, smooth. See *Rhus glabra.*

Sumac, sweet-scented. See *Rhus aromatica.*

Summer-savory. See *Satureia hortensis.*

Sundew, round-leaved. See *Drosera rotundifolia.*

Sunflower, swamp-. See *Helenium autumnale.*

Swamp squaw-weed. See *Senecio aureus.*

Swamp willow-herb. See *Epilobium palustre.*

Swamp-cabbage. See *Spathyema foetida.*

Swamp-dogwood. See *Cornus amomum.*

Swamp-hellebore. See *Veratrum viride.*

Swamp-laurel. See *Magnolia virginiana.*

Swamp-maple. See *Acer rubrum.*

Swamp-milkweed. See *Asclepias incarnata.*

Swamp-sassafras. See *Magnolia virginiana.*

Swamp-silkweed. See *Asclepias incarnata.*

Swamp-sunflower. See *Helenium autumnale.*

Swamp-willow. See *Salix nigra.*

Sweatweed. See *Althaea officinalis.*

Sweet-cicely. See *Washingtonia longistylis.*

Sweet-flag. See *Acorus calamus.*

Sweet-gum. See *Liquidambar styraciflua.*

Sweetroot. See *Polemonium reptans.*

Symphytum officinale L. **Borage family (Boraginaceae).**

Comfrey; healing-herb; blackwort; bruisewort.

Erect, perennial herb, 2 to 3 feet high, naturalized from Europe; found in waste places, Newfoundland to Minnesota, south to Maryland.

Part used.—Root (nonofficial).

Symplocarpus foetidus Nutt. Same as *Spathyema foetida.*

Tag-alder. See *Alnus rugosa.*

Tamarack. See *Larix laricina.*

Tanacetum. See *Tanacetum vulgare.*

Tanacetum vulgare L. **Aster family (Asteraceae).**

Tanacetum; tansy; double tansy; bitter-buttons; parsley-fern.

Strong-scented, perennial herb, 1½ to 3 feet high, introduced from Europe; escaped from cultivation and found along roadsides from Nova Scotia to Minnesota, south to North Carolina and Missouri.

Parts used.—Leaves and flowering tops (official in U. S. P. 1890).

Tanbark-tree. See *Tsuga canadensis.*

Tansy. See *Tanacetum vulgare.*

Tansy, double. See *Tanacetum vulgare.*

Taraxacum. See *Taraxacum officinale.*

Taraxacum officinale Weber.[a] **Chicory family (Cichoriaceae).**

Synonym.—*Taraxacum taraxacum* (L.) Karst.[a]

Taraxacum; dandelion; blowball; cankerwort.

Low, perennial weed, 5 to 10 inches high, naturalized from Europe; very abundant in lawns, meadows, and waste places throughout the United States, with the exception of the South.

Part used.—Root, collected in autumn (official).

Taraxacum taraxacum (L.) Karst. Same as *Taraxacum officinale.*

Tea, continental. See *Ledum groenlandicum.*

Tea, James-. See *Ledum groenlandicum.*

Tea, Jersey. See *Ceanothus americanus.*

Tea, Jerusalem. See *Chenopodium ambrosioides.*

Tea, Labrador. See *Ledum groenlandicum.*

Tea, Mexican. See *Chenopodium ambrosioides.*

Tea, mountain-. See *Gaultheria procumbens.*

Tea, New Jersey. See *Ceanothus americanus.*

Tea, Oswego. See *Monarda didyma.*

Tea, Spanish. See *Chenopodium ambrosioides.*

Teaberry. See *Gaultheria procumbens.*

Tephrosia virginiana Pers. Same as *Cracca virginiana.*

Tetterwort. See *Chelidonium majus* and *Sanguinaria canadensis.*

Thimbleberry. See *Rubus occidentalis.*

[a] Although the combination *Taraxacum taraxacum* (L.) Karst. should be accepted by right of priority, the usage of the Pharmacopœia is followed.

Thimbles. See *Digitalis purpurea.*

Thimbleweed. See *Rudbeckia laciniata.*

Thistle, bitter. See *Cnicus benedictus.*

Thistle, blessed. See *Cnicus benedictus.*

Thistle, Canada. See *Carduus arvensis.*

Thistle, creeping. See *Carduus arvensis.*

Thistle, cursed. See *Carduus arvensis.*

Thistle, holy. See *Cnicus benedictus.*

Thistle, St. Benedict's-. See *Cnicus benedictus.*

Thistle, spotted. See *Cnicus benedictus.*

Thorn-apple. See *Datura stramonium.*

Thoroughwort. See *Eupatorium perfoliatum.*

Thousandleaf. See *Achillea millefolium.*

Throwwort. See *Leonurus cardiaca.*

Thuja occidentalis L. **Pine family (Pinaceae).**

Arbor-vitae; white cedar; yellow cedar.

Indigenous, evergreen tree, 20 to 50 feet in height; in wet soil and along banks of streams, Canada to North Carolina, Illinois, and Minnesota. Especially abundant in Canada and the Northern States.

Parts used.—Branchlets and leaves (nonofficial).

Tiarella cordifolia L. **Saxifrage family (Saxifragaceae).**

Coolwort; false miterwort; foamflower; gemfruit.

Slender, indigenous perennial, 6 to 12 inches high, found in rich, moist woods, Nova Scotia to Minnesota, south, especially along the mountains, to Georgia and Indiana.

Part used.—Herb (nonofficial).

Tickweed. See *Hedeoma pulegioides.*

Tilia americana L. **Linden family (Tiliaceae).**

Synonym.—*Tilia glabra* Vent.

Basswood; American linden; whitewood.

Large, indigenous forest tree, 60 to 125 feet in height; in rich woods, especially along the mountains, from Canada to Georgia, west to Texas and Nebraska.

Part used.—Inflorescence of this and of other species of Tilia (nonofficial).

Tilia glabra Vent. Same as *Tilia americana.*

Tinker's-weed. See *Triosteum perfoliatum.*

Tobacco, Indian. See *Lobelia inflata.*

Toothache-tree. See *Fagara clava-herculis* and *Xanthoxylum americanum.*

Touch-me-not, pale. See *Impatiens aurea.*

Touch-me-not, spotted. See *Impatiens biflora.*

Toywort. See *Bursa bursa-pastoris.*

Tree-primrose. See *Oenothera biennis.*

Trefoil, marsh-. See *Menyanthes trifoliata.*

Trefoil, shrubby. See *Ptelea trifoliata.*

Trefoil, sour. See *Oxalis acetosella.*

Trifolium pratense L. **Pea family (Fabaceae).**

Red clover; meadow-clover; purple clover.

Perennial herb, 6 inches to 2 feet high; common in fields and meadows throughout the eastern United States; naturalized from Europe, and widely cultivated.

Part used.—Blossoms (nonofficial).

Trilisa odoratissima (Walt.) Cass. **Aster family (Asteraceae).**

Synonym.—*Liatris odoratissima* Michx.

Vanilla-plant; deer's-tongue; vanilla-leaf; Carolina vanilla.

Rather stout, native, perennial herb, 2 to 3 feet high, with fragrant leaves; in pine barrens from Virginia south to Florida and Louisiana.

Part used.—Leaves (nonofficial).

Trillium erectum L. **Lily-of-the-valley family (Convallariaceae).**

Wake-robin; ill-scented bethroot; birthroot; squawflower.

Stout, native perennial, 8 to 16 inches high, growing in rich soil in damp, shady woods from Canada south to Tennessee and Missouri.

Part used.—Rhizome of this and of several other species of Trillium (nonofficial).

Triosteum perfoliatum L. **Honeysuckle family (Caprifoliaceae).**

Feverroot; horse-gentian; tinker's-weed; white gentian; wild ipecac.

Indigenous, perennial herb, 2 to 4 feet high; in rich soil in shady locations, Quebec to Minnesota, south to Alabama and Kansas.

Part used.—Root (nonofficial).

Triticum. See *Agropyron repens.*

Triticum repens Beauv. Same as *Agropyron repens.*

Trumpetleaf. See *Sarracenia flava.*

Trumpet-milkweed. See *Lactuca canadensis.*

Trumpets. See *Sarracenia flava.*

Tsuga canadensis (L.) Carr. **Pine family (Pinaceae).**

Synonym.—*Abies canadensis* Michx.

Hemlock; hemlock-spruce; weeping spruce; tanbark-tree.

Indigenous tree, about 75 feet in height, in forests from Canada south to Alabama and Wisconsin.

Parts used.—Bark and prepared resinous exudate (nonofficial).

Tulip-poplar. See *Liriodendron tulipifera.*

Tulip-tree. See *Liriodendron tulipifera.*

Tupelo gum. See *Nyssa aquatica.*

Tupelo, large. See *Nyssa aquatica.*

Tupelo, sour. See *Nyssa ogeche.*

Turkey-corn. See *Bikukulla canadensis.*

Turkey-pea. See *Bikukulla canadensis.*

Turnera aphrodisiaca Ward. Same as *Turnera microphylla.*

Turnera microphylla Desv. **Turnera family (Turneraceae).**

Synonym.—*Turnera aphrodisiaca* Ward.

Damiana.

A small, shrubby plant, native of Lower California, Texas, and northern Mexico, growing in dry soil.

Part used.—Leaves (nonofficial).

Turnip, Indian. See *Arisaema triphyllum.*

Turnip, wild. See *Arisaema triphyllum.*

Turtle-head. See *Chelone glabra.*

Tussilago farfara L. **Aster family (Asteraceae).**

Colt's-foot; coughwort; horsefoot; gingerroot.

Perennial herb, 3 to 18 inches high, naturalized from Europe; in moist places along roadsides and brooks, northeastern United States and Minnesota to Canada.

Parts used.—Leaves and root (nonofficial).

Twinleaf. See *Jeffersonia diphylla.*

Typha latifolia L. **Cattail family (Typhaceae).**

Broad-leaved cattail; cattail-flag; bulrush.

Native marsh plant, perennial, 4 to 8 feet high; found in marshes, ditches, muddy pools, and other wet places throughout North America, except extreme northern part.

Part used.—Root (nonofficial).

Ulmus. See *Ulmus fulva.*

Ulmus fulva Michx. **Elm family (Ulmaceae).**

Synonym.—*Ulmus pubescens* Walt.

Ulmus; elm; slippery elm; red elm; moose-elm; Indian elm.

Indigenous tree, 50 to 60 feet high, growing on hills, along streams and in woods from Quebec to North Dakota, south to Florida and Texas. More common in the western part of its range.

Part used.—Bark deprived of its periderm (official).

Ulmus pubescens Walt. Same as *Ulmus fulva.*

Umbrella-tree. See *Magnolia tripetala.*

Unicorn-root, false. See *Aletris farinosa.*

Unicorn-root, true. See *Chamaelirium luteum.*

Upland-cranberry. See *Arctostaphylos uva-ursi.*

Urtica dioica L. **Nettle family (Urticaceae).**

Stinging nettle; great nettle.

Herbaceous, perennial plant, 2 to 4 feet high, with stinging hairs; naturalized from Europe and found in waste places from Canada and Minnesota south to South Carolina and Missouri.

Parts used.—Flowers, leaves, and root (nonofficial).

Uva-ursi. See *Arctostaphylos uva-ursi.*

Uvedalia. See *Polymnia uvedalia.*

Uvularia perfoliata L. **Bunchflower family (Melanthiaceae).**

Perfoliate bellwort; Mohawk-weed.

Native, perennial herb, 6 to 20 inches high; in moist woods and thickets, Quebec to Florida and Mississippi.

Part used.—Root (nonofficial).

Vagnera racemosa (L.) Morong. **Lily-of-the-valley family (Convallariaceae).**

Synonyms.—*Convallaria racemosa* L.; *Smilacina racemosa* Desf.

False Solomon's-seal; small Solomon's-seal; wild spikenard; false spikenard.

Indigenous, perennial herb, 1 to 3 feet high, found in moist woods and thickets from Canada south to Georgia and Arizona.

Part used.—Root (nonofficial).

Valerian. See *Valeriana officinalis.*

Valerian, American. See *Cypripedium hirsutum.*

Valerian, American Greek. See *Polemonium reptans.*

Valerian, garden-. See *Valeriana officinalis.*

Valeriana. See *Valeriana officinalis.*

Valeriana officinalis L. **Valerian family (Valerianaceae).**

Valeriana; valerian; garden-valerian; vandal-root.

Perennial herb, 2 to 5 feet high, native of Europe; escaped from gardens to roadsides in New York and New Jersey.

Parts used.—Rhizome and roots (official).

Vandal-root. See *Valeriana officinalis.*

Vanilla, Carolina. See *Trilisa odoratissima.*

Vanilla-leaf. See *Trilisa odoratissima.*

Vanilla-plant. See *Trilisa odoratissima.*

Velvet-plant. See *Verbascum thapsus.*

Veratrum. See *Veratrum viride.*

Veratrum viride Ait. **Bunchflower family (Melanthiaceae).**

Veratrum; American hellebore; swamp-hellebore; green hellebore.

Native, perennial herb, 2 to 7 feet high, growing in swamps, wet woods, and meadows, Canada and Alaska, Minnesota south to Georgia.

Parts used.—Rhizome and roots of this or *V. album* (official).

Verbascum thapsus L. **Figwort family (Scrophulariaceae).**

Mullein; velvet dock; velvet-plant; flannel-leaf.

Tall, erect, biennial weed, sometimes 7 feet in height; naturalized from Europe and growing in fields, pastures, and waste places, Nova Scotia to Minnesota, southward to Florida.

Parts used.—Leaves and flowers (nonofficial).

Verbena hastata L. **Vervain family (Verbenaceae).**

Vervain; simpler's-joy; wild hyssop.

Erect, indigenous perennial, 3 to 4 feet high, found in fields, meadows, and waste places, Canada to Nebraska, New Mexico, and Florida.

Parts used.—Root and herb (nonofficial).

Veronica officinalis L. **Figwort family (Scrophulariaceae).**

Common speedwell; Paul's-betony.

Perennial herb, 3 to 10 inches high; in dry fields and woods, Nova Scotia to Michigan, south to North Carolina and Tennessee.

Part used.—Herb (nonofficial).

Veronica, tall. See *Veronica virginica.*

Veronica virginica L.[a] **Figwort family (Scrophulariaceae).**

Synonym.—*Leptandra virginica* (L.) Nutt.[a]

Leptandra; Culver's-root; Culver's-physic; blackroot; Bowman's-root; tall speedwell; tall veronica.

Indigenous, perennial plant, 2 to 5 feet high, in moist, rich ground in woods, meadows, and thickets from Canada to Alabama and Nebraska.

Parts used.—Rhizome and roots (official).

Vervain. See *Verbena hastata.*

Viburnum dentatum L. **Honeysuckle family (Caprifoliaceae).**

Arrowwood; mealy-tree.

Smooth, indigenous shrub, about 15 feet in height, growing on low ground and in damp woods and thickets from New Brunswick and Ontario south along the mountains to Georgia, and westward to Minnesota.

Part used. —Bark (nonofficial).

Viburnum lentago L. **Honeysuckle family (Caprifoliaceae).**

Nannybush; sheepberry; sweet viburnum.

An indigenous shrub, sometimes a small tree; in rich soil from Canada to Georgia and Missouri.

Part used.—Bark of the root of this species or of *V. prunifolium* official under the name "Viburnum prunifolium."

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[a] Some authors hold that this plant belongs to the genus Leptandra and that its name should be *Leptandra virginica* (L.) Nutt. The Pharmacopœia is here followed.

Viburnum opulus. See *Viburnum opulus* L.

Viburnum opulus L. **Honeysuckle family (Caprifoliaceae).**

Viburnum opulus; cramp-bark; high-bush cranberry; squawbush.

Indigenous shrub, 4 to 10 feet in height, found in low, rich woods and borders of fields from New Jersey, Michigan, and Oregon, northward.

Part used.—Bark (official).

Viburnum prunifolium. See *Viburnum lentago* and *V. prunifolium* L.

Viburnum prunifolium L. **Honeysuckle family (Caprifoliaceae).**

Black haw; sloe; stagbush.

Indigenous shrub or small tree, growing in dry woods and thickets and on rocky hillsides, Connecticut to Florida, west to Michigan and Texas. Most abundant in the South.

Part used.—Bark of the root of this species or of *V. lentago* official under the name "Viburnum prunifolium."

Viburnum, sweet. See *Viburnum lentago.*

Vine-maple. See *Menispermum canadense.*

Viola odorata L. **Violet family (Violaceae).**

English violet; sweet violet; March violet.

Low herb, native of Europe; escaped from gardens, Nova Scotia to New York and New Jersey, and on the Pacific coast.

Part used.—Flowers (nonofficial).

Viola pedata L. **Violet family (Violaceae).**

Bird's-foot violet; wood-violet; snake-violet.

Native plant, perennial, 3 to 10 inches high, occurring in dry fields and on hillsides from Maine to Minnesota, south to Florida and Missouri.

Parts used.—Herb and root (nonofficial).

Viola tricolor L. **Violet family (Violaceae).**

Pansy; heartsease.

Small herb, 4 to 12 inches high, introduced from Europe; found in waste places, sparingly escaped from gardens.

Part used.—Flowering herb (nonofficial).

Violet, bird's-foot. See *Viola pedata.*

Violet, dog's-tooth. See *Erythronium americanum.*

Violet, English. See *Viola odorata.*

Violet, March. See *Viola odorata.*

Violet, rattlesnake-. See *Erythronium americanum.*

Violet, snake-. See *Viola pedata.*

Violet, sweet. See *Viola odorata.*

Violet, wood-. See *Viola pedata.*

Violet-bloom. See *Solanum dulcamara.*

Virginia creeper. See *Parthenocissus quinquefolia.*

Virgin's-bower. See *Clematis virginiana.*

Viscum flavescens Pursh. Same as *Phoradendron flavescens.*

Vomitwort. See *Lobelia inflata.*

Wafer-ash. See *Ptelea trifoliata.*

Wahoo. See *Euonymus atropurpureus.*

Wake-robin. See *Arisaema triphyllum* and *Trillium erectum.*

Walnut, white. See *Juglans cinerea.*

Wartwort. See *Gnaphalium uliginosum.*

Washingtonia longistylis (Torr.) Britton. **Parsley family (Apiaceae).**

Synonym.—Osmorrhiza longistylis DC.

Sweet-cicely; anise-root; sweet chervil.

Erect, rather stout, perennial herb, 2 to 3 feet high, native; in rich, moist woods and banks of streams from Canada to Alabama and Texas.

Part used.—Root (nonofficial).

Water-avens. See *Geum rivale.*

Water-bugle. See *Lycopus virginicus.*

Watercup. See *Sarracenia flava* and *S. purpurea.*

Watercup, yellow-flowered. See *Sarracenia flava.*

Water-eryngo. See *Eryngium yuccifolium.*

Water-flag. See *Iris versicolor.*

Water-hemlock. See *Cicuta maculata.*

Water-hoarhound. See *Lycopus virginicus.*

Water-lily. See *Castalia odorata.*

Water-lily, sweet-scented. See *Castalia odorata.*

Water-pepper. See *Polygonum hydropiper.*

Water-shamrock. See *Menyanthes trifoliata.*

Water-smartweed. See *Polygonum punctatum.*

Waxberry. See *Myrica cerifera.*

Wax-myrtle. See *Myrica cerifera.*

Waxwork. See *Celastrus scandens.*

Waythorn. See *Rhamnus cathartica.*

White-bark. See *Populus alba.*

Whiteroot. See *Asclepias tuberosa.*

Whitethorn. See *Crataegus oxyacantha.*

Whitewood. See *Liriodendron tulipifera* and *Tilia americana.*

Wickopy. See *Dirca palustris.*

Wickup. See *Chamaenerion angustifolium* and *Epilobium palustre.*

Willow, black. See *Salix nigra.*

Willow, European. See *Salix alba.*

Willow, pussy-. See *Salix nigra.*

Willow, rose-. See *Cornus amomum.*

Willow, swamp-. See *Salix nigra.*

Willow, white. See *Salix alba.*

Willow-herb, great. See *Chamaenerion angustifolium.*

Willow-herb, night. See *Oenothera biennis.*

Willow-herb, swamp. See *Epilobium palustre.*

Wingseed. See *Ptelea trifoliata.*

Winterberry, Virginia. See *Ilex verticillata.*

Winterbloom. See *Hamamelis virginiana.*

Wintergreen. See *Gaultheria procumbens.*

Wintergreen, bitter. See *Chimaphila umbellata.*

Witch-hazel. See *Hamamelis virginiana.*

Woodbine, wild. See *Gelsemium sempervirens.*

Wood-fern, evergreen. See *Dryopteris marginalis.*

Wood-sorrel, white. See *Oxalis acetosella.*

Wood-violet. See *Viola pedata.*

Worm-grass. See *Spigelia marilandica.*

Wormseed. See *Chenopodium anthelminticum.*

Wormseed, American. See *Chenopodium ambrosioides.*

Wormwood. See *Artemisia absinthium.*

Wormwood, Roman. See *Ambrosia artemisiaefolia.*

Xanthium spinosum L. **Ragweed family (Ambrosiaceae).**

Spiny clotbur; spiny burseed; thorny clotweed; thorny burweed.

An annual weed, 1 to 3 feet high, naturalized from Europe or Asia; in waste ground, Ontario to Florida, westward to Missouri and Texas.

Part used.—Leaves (nonofficial).

Xanthorrhiza apiifolia L'Her. **Crowfoot family (Ranunculaceae).**

Shrub yellowroot; southern yellowroot.

Low, shrubby, indigenous perennial, 1 to 2 feet high, growing in woods and along river banks, southwestern New York to Florida, chiefly in the mountains.

Parts used.—Rhizome and roots (nonofficial).

Xanthoxylum. See *Fagara clava-herculis* and *Xanthoxylum americanum.*

Xanthoxylum americanum Mill. **Rue family (Rutaceae).**

Synonym.—*Xanthoxylum fraxineum* Willd.

Xanthoxylum; northern prickly ash; toothache-tree.

Indigenous shrub or small tree, maximum height about 25 feet; common in woods and thickets and along river banks from Virginia, Missouri, and Nebraska northward to Canada.

Parts used.—Bark of this or of *Fagara clava-herculis* official under the name "Xanthoxylum." Berries (nonofficial).

Xanthoxylum clava-herculis L. Same as *Fagara clava-herculis.*

Xanthoxylum fraxineum Willd. Same as *Xanthoxylum americanum.*

Yam, wild. See *Dioscorea villosa.*

Yarrow. See *Achillea millefolium.*

Yellowroot. See *Coptis trifolia, Hydrastis canadensis,* and *Jeffersonia diphylla.*

Yellowroot, shrub. See *Xanthorrhiza apiifolia.*

Yellowroot, southern. See *Xanthorrhiza apiifolia.*

Yellowthorn. See *Fagara clava-herculis.*

Yellowwood. See *Fagara clava-herculis.*

Yerba buena. See *Micromeria chamissonis.*

Yerba reuma. See *Frankenia grandifolia.*

Yerba santa. See *Eriodictyon californicum.*

Youthwort. See *Drosera rotundifolia* and *Heracleum lanatum.*

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THE PHILADELPHIA
JAN 26 1906
MUSEUMS

THE PHILADELPHIA
MAR 7 - 1906

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 90.

B. T. GALLOWAY, *Chief of Bureau.*

MISCELLANEOUS PAPERS.

I. THE STORAGE AND GERMINATION OF WILD RICE SEED.
By J. W. T. DUVEL, *Assistant.*

II. THE CROWN-GALL AND HAIRY-ROOT DISEASES OF THE APPLE TREE.
By GEORGE G. HEDGCOCK, *Assistant.*

III. PEPPERMINT.
By ALICE HENKEL, *Assistant.*

IV. THE POISONOUS ACTION OF JOHNSON GRASS.
By A. C. CRAWFORD, *Pharmacologist.*

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BUREAU OF PLANT INDUSTRY.

B. T. GALLOWAY,

Pathologist and Physiologist, and Chief of Bureau.

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SEED AND PLANT INTRODUCTION AND DISTRIBUTION.

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[a] The four papers constituting this Bulletin were issued in separate form on September 7, November 17, December 28, 1905, and January 17, 1906, respectively.

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THE PHILADELPHIA
MAR 7 - 1906
MUSEUMS

MISCELLANEOUS PAPERS.

B. P. I.—178.

I.—THE STORAGE AND GERMINATION OF WILD RICE SEED.[a]

By J. W. T. Duvel, *Assistant in the Seed Laboratory.*

INTRODUCTION.

The seed of wild rice, sometimes called Indian rice or water oats (*Zizania aquatica* L.), has always been a very valuable food among the Indians, especially those of the upper Mississippi Valley. Of recent years wild rice has found a place on the menu cards of some of our best American hotels. The rich and highly nutritious grains, together with the slightly smoky flavor it has when properly prepared, make it an extremely palatable article of diet. If it were not for the difficulties of harvesting the seed and preparing the finished product for market it is probable that wild rice would find a place in many American homes.

At present, however, the greatest interest in wild rice is created by the value of the seed as a food for wild waterfowl, particularly wild ducks. As a result of this interest the propagation of wild rice from seed has become a question of considerable importance, especially to the members of the gunning clubs throughout the United States and Canada.

DISTRIBUTION.

The distribution of wild rice is now reported from New Brunswick and Assiniboia south to Florida, Louisiana, and Texas. There are, however, comparatively few localities in which it grows abundantly.

[a] Wild rice is considered one of the most important foods for wild ducks and other waterfowl, and a large number of inquiries have been received from members of gunning clubs throughout the United States asking where good, germinable seed can be secured. It is quite generally recognized that wild rice seed loses its vitality if allowed to become dry, and better methods of storing the seed during the winter have long since been demanded.

The results of investigations begun two years ago show that wild rice seed can be handled without any deterioration in vitality if it is harvested and stored according to methods outlined in the present paper.

J. W. T. Duvel, *Acting Botanist in Charge of Seed Laboratory.*

Seed Laboratory,
Washington, D. C., July 20, 1905.

Good reasons exist for assuming that this area can be extended to include all fresh-water lakes, as well as swamps and river bogs, when the water does not become stagnant, throughout the whole of North America south of latitude 55° north. Wild rice also grows luxuriantly along the lower parts of many of the rivers of the Atlantic Coast States, the waters of which are affected by the action of the tide to a considerable degree, and consequently contain an appreciable quantity of salt. It has been shown[a] that the maximum degree of concentration of salt water in which wild rice plants can grow successfully is equivalent to a 0.03 normal solution of sodium chlorid. This concentration corresponds to 0.1755 per cent by weight of sodium chlorid, which is sufficient to give a slight salty taste to the water.

HABITAT.

While it is well recognized that the habitat of the wild rice plant is in shallow fresh water, it is now known that it will grow luxuriantly in water containing little less than two-tenths of 1 per cent of sodium chlorid. Occasional plants have been found growing in water which contained, for short periods at least, nearly double that amount of salt. These facts indicate the possibility of a much wider range of conditions to which this plant may be subjected without hindering its development. It is not beyond the range of possibility—indeed, it is quite probable—that by careful selection plants may be obtained which will thrive on soil that is comparatively dry, at least in places in which the water can be drawn off gradually during the latter part of the growing season.

In September, 1904, Mr. G. C. Worthen, of the Bureau of Plant Industry, collected a cluster of wild rice plants which were growing on the Potomac Flats, near Washington, D. C., in soil which was sufficiently dry to permit the use of a 2-horse mowing machine for cutting down the rank growth of vegetation. This was newly made land, and in all probability the seed giving rise to this cluster of plants was pumped in with the dirt from the Potomac River the year previous.

This amphibious type once established, it will undoubtedly carry with it a strain of seed which can withstand considerable drying without any marked injury to its vitality. Such being true, the methods and difficulties of propagation from seed would be greatly simplified.

Simultaneous with establishing an amphibious type should come the selection of seed plants which are capable of retaining their seed until the larger part of it has reached maturity. These two steps once made, the future of wild rice as a cereal will be assured.

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[a] The Salt Water Limits of Wild Rice. Bulletin No. 72, Part II, Bureau of Plant Industry, United States Department of Agriculture, 1905.

GERMINATION OF THE SEED.

The greatest difficulty to be overcome in extending the area for growing wild rice is the poor germination of the commercial seed. Inasmuch as wild rice constitutes one of the most important foods of wild ducks and other wild waterfowl, many individuals and most of the gunning clubs east of the Rocky Mountains have been asking the question, How can we propagate wild rice from seed in order to establish better feeding and fattening grounds for our game birds?

The many failures in the propagation of wild rice from seed have been due to the use of seed that had become dry before sowing, or to the fact that the seed when sown fresh in the autumn had been eaten by ducks or other animals or was carried away by heavy floods before germination took place.

It is now very generally known that the seed of wild rice, if once allowed to become dry, will not germinate, save possibly an occasional grain. In its natural habitat the seed, as soon as mature, falls into the water and sinks into the mud beneath, where it remains during the winter months, germinating the following spring if conditions are favorable.

Heretofore the plan generally followed, and the one usually recommended by those who have given some attention to the propagation of wild rice, was practically that of natural seeding; that is, to gather the seed in the autumn, as soon as thoroughly mature, and, while still fresh, to sow it in 1 to 3 feet of water.

FALL SEEDING VERSUS SPRING SEEDING.

It must be remembered that the bulk of the seed remains dormant during the winter, germinating first the spring after maturing; consequently, with but few exceptions, fall seeding is unsatisfactory and unreliable. Fall seeding is likely to prove a failure for three reasons: (1) Wild ducks and other animals of various kinds eat or destroy the seed in considerable quantity before it has had time to germinate the following spring; (2) much of the seed is frequently covered so deeply with mud that washes in from the shore during the winter that the young plants die of suffocation and starvation before they reach the surface; (3) in some cases a large quantity of the seed is carried away from the place where sown by the high waters and floating ice prevalent during the latter part of the winter and early spring.

In exceptional cases these difficulties can be overcome; under which circumstances autumn sowing may be preferable to spring sowing. In the majority of cases, however, much better results will be obtained if the seed is properly stored and sown in the early spring, as soon as the danger of heavy floods is passed and the water level approaches normal.

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In sowing the seed considerable care must be exercised in selecting a suitable place, securing the proper depth of water, etc. Good results can be expected if the seed is sown in from 1 to 3 feet of water which is not too stagnant or too swiftly moving, with a thick layer of soft mud underneath.[a] It is useless to sow wild rice seed on a gravelly bottom or in water where the seed will be constantly disturbed by strong currents.

Previous to this time, save in a few reported cases, the seed which was allowed to dry during the winter and was sown the following spring gave only negative results. It is now definitely known that wild rice, if properly handled, can be stored during the winter without impairing the quality of germination to any appreciable degree, and that it can be sown the following spring or summer with good success.

DIRECTIONS FOR STORING THE SEED.

The vitality of wild rice seed is preserved almost perfectly if kept wet in cold storage—Nature's method of preservation. This method of storage implies that the seed has been properly harvested and cared for up to the time of storage. The seed should be gathered as soon as mature, put loosely into sacks (preferably burlap), and sent at once to the cold-storage rooms. If the wild rice fields are some distance from the cold-storage plant the sacks of seed should be sent by express, and unless prompt delivery can be guaranteed it is not advisable to send by freight even for comparatively short distances. It is very important that the period between the time of harvesting and the time when the seed is put into cold storage be as short as possible. If this time is prolonged to such an extent as to admit of much fermentation or to allow the seed near the outside of the bags to become dry during transit, its vitality will be greatly lowered.

It is not practicable to give any definite length of time which may elapse between harvesting and storing, inasmuch as the temperature, humidity, and general weather conditions, as well as the methods of handling the seed, must be taken into consideration. Let it suffice to say, however, that the vitality of the seed will be the stronger the sooner it is put into cold storage after harvesting.

As soon as the seed is received at the cold-storage plant, while it is still fresh and before fermentation has taken place, it should be put into buckets, open barrels, or vats, covered with fresh water, and placed at once in cold storage. If there is present a considerable quantity of light immature seed or straw, broken sticks, etc., it will be profitable to separate this from the good seed by floating in water

[a] Wild Rice: Its Uses and Propagation. Bulletin No. 50, Bureau of Plant Industry, United States Department of Agriculture, 1903.

preparatory to storing. The storage room should be maintained at a temperature just above freezing—what the storage men usually designate as the "chill room."

When taken from cold storage in the spring the seed must not be allowed to dry out before planting, as a few days' drying will destroy every embryo.

Seed which was stored under the foregoing conditions from October 19, 1903, to November 15, 1904, 393 days, germinated from 80 to 88 per cent. Another lot of seed, which was stored on October 6, 1904, and tested for vitality on April 17, 1905, germinated 79.8 per cent.

Plate I shows the luxuriant growth made by the seed which was kept wet and stored at a temperature of 32° to 34° F. for 393 days.

DETAILED CONDITIONS AND RESULTS OF STORAGE EXPERIMENTS.

The foregoing conclusions are based on the results obtained from two series of experiments, as follows:

In October, 1903, a box of wild rice seed was received from Ontario, Canada. This seed, as soon as gathered, was loosely packed in moist sphagnum and sent by express to the Seed Laboratory of the United States Department of Agriculture. After a few days, while it was yet moist and before any fermentation had taken place, the seed was divided into four lots for special treatment, as follows:

(1) Seed submerged in water and placed in cold storage at a temperature of 32° to 34° F.

(2) Seed submerged in water and placed in cold storage at a temperature of 12° F. The seed was soon embedded in a solid mass of ice and remained so until samples were taken for test.

(3) Seed, without the addition of water, put into cloth bags and kept in cold storage at a temperature of 32° to 34° F.

(4) Seed, without the addition of water, put into cloth bags and kept in cold storage at a temperature of 12° F.

In October, 1904, a second consignment of seed was received from Minnesota, and the following additional storage experiments were made by Mr. C. S. Scofield, of the Bureau of Plant Industry.

(5) Seed submerged in water and placed in cold storage at a temperature of 32° to 34° F., as in No. 1.

(6) Seed submerged in water and placed in cold storage at a temperature of 12° F., as in No. 2.

(7) Seed submerged in water in a galvanized-iron bucket and stored on the roof of the laboratory building. The water was changed daily when not frozen.

(8) Seed submerged in water in a galvanized-iron bucket and stored on the roof of the laboratory building, as in No. 7. In this case the water was not changed save to replace the loss due to evaporation.

(9) The conditions for No. 9 were the same as those for No. 8, except that air was forced into the water daily when not frozen solid.

Samples of seed were taken from the different lots and tested for vitality at irregular intervals throughout the time of storage, which, in the former series, extended over a period of approximately thirteen months and in the latter series over a period of little more than six months.

Experiments Nos. 1 and 5.—The seed which was submerged in water and stored in the "chill room" showed no deterioration in vitality. The results of the final tests gave a germination varying from 79.8 to 88 per cent. This is practically Nature's method of preserving the vitality of the seed during the winter.

Experiments Nos. 2 and 6.—The seed which was submerged in water and stored at a temperature of 12° F. was all killed before the spring following the date of storage. Soon after being placed in storage the water was frozen solid and the seeds were embedded in a mass of ice, in which condition they remained throughout the experiment, a portion being cut out from time to time for germination tests. The complete loss of vitality in these two lots of seed is attributed not to the freezing directly, but to the thorough desiccation as a result of the continuous low temperature.

Experiments Nos. 3 and 4.—The samples of seed which were stored in cloth bags at the temperatures of 32° to 34° F. and of 12° F. had, for all economic purposes, entirely lost their vitality. The average percentage of germination, as shown by the 37 tests made from each of the two lots, was less than five-tenths of 1 per cent.

Experiment No. 7.—The seed which was submerged in water and stored on the roof of the laboratory building, the water being changed daily, showed a good percentage of germination when the last vitality tests were made. If only a small quantity of seed is desired for the spring planting and cold storage can not be readily secured, good results may be obtained by this treatment; but it is much less certain and probably more expensive than keeping the seed in cold storage, and for this reason is not recommended. The success of this method will likewise depend largely on the temperature of the water.

Experiments Nos. 8 and 9.—On April 22, 1905, samples taken from each of these two lots of seed showed a marked deterioration in vitality. Thoroughly mixed samples from No. 8 showed a vitality of only 58 per cent, while No. 9 had deteriorated to 14.3 per cent.

PACKING FOR TRANSPORTATION.

Too much care can not be given to the matter of packing the seed for transportation, for unless the packing is properly done the vitality of the seed will be destroyed during transit. What is here said applies to fresh seed which is to be sown in the autumn, as well as to seed which has been kept in cold storage during the winter. It must not be forgotten, however, that the vitality of cold-storage seed is more quickly destroyed on drying than that of fresh seed.

For transportation the seed should be carefully packed, with moist sphagnum, cocoanut fiber, or fine excelsior, in a loosely slatted box. If the time of transportation does not exceed five or six days no special precautions need be taken as to the temperature. During the period of transportation it is quite probable that some of the seed will germinate, but if sown at once growth will not be retarded and the roots will soon penetrate the soil and anchor the young plants.

If the time of transportation is necessarily long, it is recommended, if the best results are desired, that some provision be made for a reduced temperature. The nearer the temperature approaches that of freezing the better. It has been demonstrated, however, that a fair percentage of seed will remain germinable for a considerable time if packed as above described.

On October 10, 1904, Mr. C. S. Scofield sent a small quantity of wild rice, packed in moist sphagnum moss in a well-ventilated box, to Doctor De Vries, of Amsterdam, Holland. On October 14 or 15 this box was placed in cold storage on the steamer in New York Harbor. The box of seed was received by Doctor De Vries in good condition on November 2, twenty-one days after the seed was packed for shipment.

METHODS OF MAKING GERMINATION TESTS.

The samples were tested (1) between folds of blotting paper—our regular method for testing the germination of most seeds—and (2) in water, Nature's method of sowing wild rice seed. The latter method gave much better results and was the one finally adopted for the laboratory tests. The seed should be covered with water, the water in the dishes to be changed daily.

Plate I shows the importance of making the germination tests in water, as described in the foregoing paragraph. The seed was covered with water and placed in a germinating chamber maintained at an alternating temperature of 20° C. (68° F.) for eighteen hours, and 30° C. (84° F.) for six hours, until the majority of the seeds had germinated. At this stage the dish containing the seeds was transferred to the worktable, which was exposed to the temperature of the laboratory—approximately that of a living-room. The water in the

dish was changed daily during the period of germination, and water was afterwards added at irregular intervals to replace the loss by evaporation.

Plate II shows somewhat in detail the different stages in the germination of wild rice seeds. The seeds and seedlings are shown in natural size. In *b* and *c* the first sheath has just burst through the seed coats, taking a position at right angles to the seed proper. The lateral roots begin to emerge when the first sheath leaf has attained a length of ½ to 1½ inches. From this time growth continues rapidly, and by the time the seedlings are 2 or 3 inches long the root system is very well developed (*f* and *g*). At this stage under favorable conditions the plants have a good hold in the soil and will not be washed away by an ordinary freshet. The relative position of the actively growing seedling is always at right angles to that of the old seed, as shown in *f* and *g*.

EFFECT OF TEMPERATURE ON GERMINATION.

Germination tests were made at constant and alternating temperatures, ranging from 15° to 35° C. (59° to 95° F.). While no effort was made to show the minimum and maximum temperatures of germination, the percentage was somewhat reduced at a constant temperature of 35° C., and the maximum is not much above that. All of the other temperatures gave good results. The lower temperatures, however, were slightly more favorable than the higher. These facts are valuable to show that the wild rice plant can thrive in either warm or cold water, but better, perhaps, in northern than in southern latitudes.

SUMMARY.

(1) Under no circumstances should wild rice seed which is intended for planting be allowed to dry. Dried seed will germinate but rarely and should never be sown.

(2) Wild rice seed can be stored without deterioration if it is gathered as soon as matured, put into barrels or tanks, covered with fresh water, and, before fermentation has set in, stored at a temperature of 32–34° F. Seed treated in this way germinated as high as 88 per cent after being in storage 393 days. Fresh seed seldom germinates better, and usually not so well.

(3) After the seed is taken from cold storage it should not be allowed to dry. The vitality of cold-storage seed is destroyed on drying even more quickly than that of fresh seed.

(4) For transportation the seed should be packed in moist sphagnum, cocoanut fiber, or fine excelsior. If not more than five or six days are required for transit, no special precautions need be taken for controlling the temperature; but if the time for transportation exceeds

six days, provision should be made for a temperature sufficiently low to prevent marked fermentation. A temperature approximately freezing will give the most satisfactory results.

(5) Wild rice can be sown either in the autumn or in the spring. Spring sowing is preferable, thus avoiding the danger of having the seed eaten or destroyed by wild ducks or other animals during the fall or winter, or of its being buried or washed away by the heavy floods of late winter or early spring.

(6) Wild rice should be sown in the spring in from 1 to 3 feet of water which is neither too stagnant nor too swiftly moving, as soon as the danger of heavy floods is passed.

(7) Wild rice is of the greatest importance as a food for wild waterfowl, likewise a delicious breakfast food for man, and the area in which it is extensively grown should be extended. It will grow luxuriantly in either warm or cold water; furthermore, it can be grown successfully in water which is slightly salty to the taste.

(8) In determining the vitality of any sample of wild rice seed the germination tests should be made in water—the condition under which the self-sown seed germinates.

(9) The seed will germinate well at temperatures ranging from 15° to 30° C. The maximum temperature of germination is above 35° C. (95° F.), but better results are obtained at lower temperatures.

DESCRIPTION OF PLATES I AND II.

PLATE I. Wild rice growing in water. This seed was submerged at a temperature of 32–34° F. for approximately thirteen months. In making the germination test the seed was covered with water and placed in a germinating chamber maintained at a temperature of 20° C. (68° F.) for eighteen hours, and at 30° C. (86° F.) for six hours. After the majority of the seeds had germinated the dish was transferred to the worktable of the Seed Laboratory.

PLATE II. Progressive stages in the development of wild rice seedlings; *f* and *g*, seedlings showing the relative position of the growing seedlings and the parent seed, which take a position at right angles to each other when grown normally in water. (Natural size.)

WILD RICE GROWING IN WATER AFTER BEING KEPT WET IN COLD STORAGE AT A TEMPERATURE OF 32-34° F., FROM OCTOBER 19, 1903, TO NOVEMBER 15, 1904.

STAGES OF GERMINATION OF WILD RICE, SHOWING THE DEVELOPMENT OF THE ROOT SYSTEM AND THE RELATIVE POSITION OF THE SEEDLING AND THE PARENT SEED. NATURAL SIZE.

II.—THE CROWN-GALL AND HAIRY-ROOT DISEASES OF THE APPLE TREE.

By George G. Hedgcock, *Assistant in Pathology, Vegetable Pathological and Physiological Investigations.*

INTRODUCTION.

The diseases of the apple which have been classed under the name crown-gall have, during the last few years, attracted much attention, due partly to an increase of these diseases and partly to the enacting of more stringent State laws governing the shipment and inspection of trees.

A series of investigations into the nature of crown-gall upon the apple, pear, raspberry, peach, almond, grape, rose, and other plants has been in progress for some time in the Mississippi Valley Laboratory of the Bureau of Plant Industry at St. Louis, Mo., and also at other points in the Mississippi Valley. It is not to be assumed, however, that such diseases are more common in this locality than in some other portions of the United States. Apple crown-gall and hairy-root have been found in all nurseries that have been examined in various portions of the country.

This preliminary report is sent out, not with the intention of giving the results of all our investigations, but for the purpose of calling the attention of apple-tree growers to the different diseases hitherto known as apple crown-gall, and to endeavor to interest them in the collection of data regarding the predisposition of varieties to these diseases.

TWO DISTINCT DISEASES, CROWN-GALL AND HAIRY-ROOT.

Our investigations have resulted first in separating apple crown-gall into two diseases, which are considered distinct. The disease now designated as crown-gall is a callous-like gall growth of hypertrophied tissue following wounds on some portion of the root system of the tree, which rarely occurs above the ground on parts of the trunk or limbs. (See Pl. III, figs. 1 and 2.)

The malady now called the hairy-root disease is evidently the same as the one first given this name by Stewart, Rolfs, and Hall in Bulletin 191 of the New York State Experiment Station. It is characterized both in seedlings (Pl. IV, fig. 1, and Pl. V, fig. 2) and in grafted or

budded trees (Pl. III, figs. 3 and 4) by a stunted root system, accompanied with an excessive production of small fibrous roots, often originating in clusters from the main root, or taproot. Galls often occur in connection with hairy-root, but these are a result of wounds rather than a form of this disease. Seedlings of the hairy-root type, unless wounded, remain free from galls.

TYPES OF APPLE CROWN-GALL.

Apple crown-gall is of two types. A hard callous form is common on grafted trees at the union of the root and scion, and at any other point of the root system where wounds occur in either the cultivation or transplanting of trees (Pl. III, fig. 1). The results of extensive inoculations with this type have failed to prove that this disease is of a contagious nature.

A second type is a soft form more common on seedlings (Pl. IV, fig. 2), occurring more rarely on grafted trees (Pl. III, fig. 2). These softer galls resemble those of the raspberry and peach, in that they are soft and often rot off. It is not certain, however, that they, like the latter, are replaced the following year by a new gall growth from the adjacent live tissues of the host, nor is there proof yet that they are of a contagious nature.

EFFECT UPON THE LENGTH OF LIFE OF THE APPLE TREE.

Careful data are being collected from orchards and nurseries as to the effect of these diseases upon the life and fruitfulness of trees. Any information as to the locality of orchards in which diseased trees have been planted will be highly appreciated. In our crown-gall orchard there are more than 200 trees diseased with the hard type of crown-gall, and 200 healthy trees of the same grade planted under similar conditions. After two years' growth six of the crown-gall trees and nine of the healthy ones have died. No difference in the growth of the trees is noticeable. However, it can not be assumed from the results so far that, on the one hand, the disease may not yet shorten the life of the trees, or, on the other, that the trees may not entirely overcome its effects. A tree having crown-gall on its roots, however, can never be correctly graded with a smooth-rooted tree. The root system of a healthy fibrous-rooted apple tree is shown in Plate V, figure 1.

SUGGESTIONS TO NURSERYMEN.

Nurserymen are advised to be careful in the selection of seedlings for grafting and budding. All rough, warty, or galled seedlings should be thrown out, for most of them will form rough-rooted trees. Seedlings with tufted or hairy roots should also be rejected, for these,

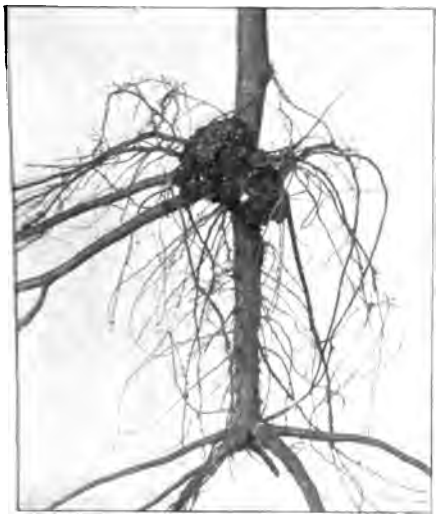

FIG. 1.—APPLE CROWN-GALL ON GRAFTED TREE.

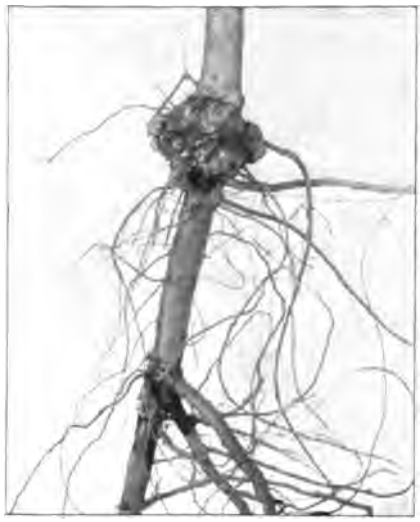

FIG. 2.—APPLE CROWN-GALL ON TRANSPLANTED SEEDLING.

FIG. 3.—HAIRY-ROOT DISEASE ON GRAFTED APPLE TREE.

FIG. 4.—HAIRY-ROOT DISEASE ON GRAFTED APPLE TREE.

FIG. 1.—APPLE SEEDLINGS DISEASED WITH HAIRY-ROOT.

FIG. 2.—APPLE SEEDLINGS DISEASED WITH SOFT CROWN-GALL.

FIG. 1.—HEALTHY FIBROUS-ROOTED APPLE TREE, POT GROWN.

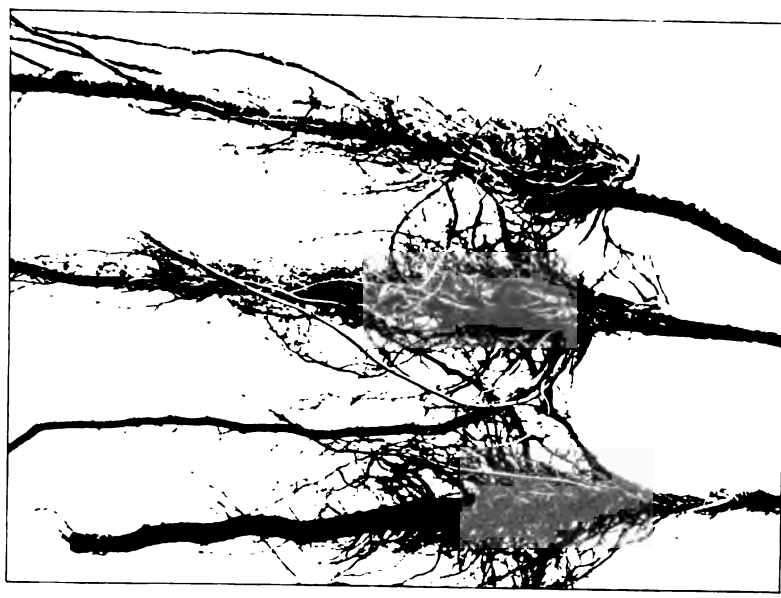

FIG. 2.—APPLE SEEDLINGS DISEASED WITH HAIRY-ROOT.

as shown by our experiments, develop into hairy-rooted trees with a very deficient root system. The hairy-root disease, as it appears from the results of two years' experiments, is not contagious. It is hoped in the near future to be able to offer some practical means of reducing the percentage of trees affected with these diseases in the nursery.

DATA DESIRED.

The hearty cooperation of nurserymen and orchardists in securing data is desired. It is hoped to secure the help of the leading nurserymen of this country in getting an accurate count from each nursery of the number of diseased trees in at least one row of every variety in all fields where the trees are all dug in one season. Such data are desired from every locality where apple trees are grown. Printed blanks with directions for tabulating such data have been provided and these will be sent to all who request them. Address the Mississippi Valley Laboratory, St. Louis, Mo.

III.—PEPPERMINT.[a]

By ALICE HENKEL, *Assistant, Drug-Plant Investigations.*

DESCRIPTION.

One of the most important essential oils produced in the United States is distilled from the peppermint plant and its varieties. The three kinds of mint grown in this country for the distillation of peppermint oil are the so-called American mint (*Mentha piperita* L.), the black mint (*Mentha piperita vulgaris* Sole), and the white mint (*Mentha piperita officinalis* Sole), the two last named being varieties of the American mint.

The American mint, although introduced from England many years ago, is so called from the fact that it has long been cultivated in this country, and the name "State mint" has been applied to it in the State of New York for the same reason.

The peppermint, or American mint, is now naturalized in many parts of the eastern United States, occurring in wet soil from the New England States to Minnesota, south to Florida and Tennessee. It is an aromatic perennial belonging to the mint family (Menthaceae), and propagates by means of its long, running roots (fig. 1). The smooth, square stems are erect and branching, from 1 to 3 feet in height, bearing dark-green, lance-shaped leaves, which are from 1 to 2 inches long, and from one-half to 1 inch wide. The leaves are pointed at the apex, rounded or narrowed at the base, sharply toothed, smooth on both sides, or with hairy veins on the lower surface. The flowers are borne in whorls in dense, terminal spikes; they are purplish, with a tubular, five-toothed calyx, and a four-lobed corolla. (Fig. 2.)

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[a] In response to a steady demand for information relating to the peppermint industry, Miss Alice Henkel, Assistant in Drug-Plant Investigations, has been requested to bring together the most important facts regarding the history, culture, and utilization of the peppermint plant. The information here presented has been obtained in large part from scattered articles on the subject, and in part from experience with the plant in the Testing Gardens of the Department of Agriculture.

RODNEY H. TRUE, *Physiologist in Charge.*

OFFICE OF DRUG-PLANT INVESTIGATIONS,
Washington, D. C., October 14, 1905.

The two varieties mentioned are closely related botanically, although in general appearance they are quite different. The variety known as black mint (*Mentha piperita vulgaris*) has purple stems and slightly toothed, dark-green leaves, while the white mint (*Mentha piperita officinalis*) has green stems, with brighter green leaves, which are more lance-shaped and more deeply toothed. Black mint is much more hardy and productive than either the American mint or the white mint, and is grown on nearly all peppermint farms in this country. The white mint, which produces a fine grade of oil, is rarely cultivated on a commercial scale in this country on account of its inability to withstand the climate and its smaller yield of essential oil.

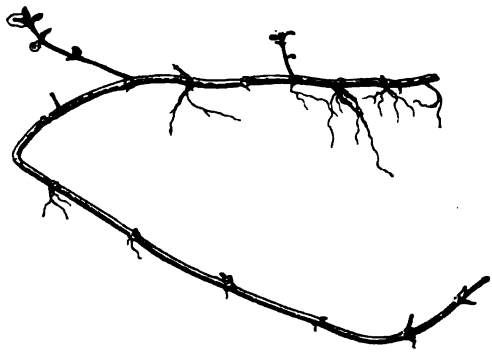

FIG. 1.—Peppermint "runners," showing method of propagation.

The oils spoken of as Japanese and Chinese "peppermint" oils are not obtained from the true peppermint plant, but are distilled from entirely different species, namely, *Mentha arvensis piperascens* Malinvaud and *Mentha arvensis glabrata* Holmes, respectively.

FIG. 2.—Leaves and flowering top of peppermint.

COUNTRIES WHERE GROWN.

The most important peppermint-producing countries are the United States, England, and Japan. Peppermint is grown on a smaller scale in Germany, France, Italy, Russia, China, and southern India.

In Japan, peppermint cultivation is said to have been undertaken before the Christian era. The plant grown there is not, as already stated, the peppermint cultivated in our country, but *Mentha arvensis piperascens*, which is entirely dis-

tinct from the true peppermint, not only botanically but also in taste and odor.

Peppermint is cultivated on many drug farms in England, especially at Mitcham, the middle of the eighteenth century marking the beginning of peppermint cultivation in that country. Up to 1805, however, there were no stills at Mitcham, and the crops obtained there were sent to London for distillation. About 1850, at which time the peppermint industry in England was at its height, the effect of American competition began to be felt, and caused a decided check in the production.

PEPPERMINT CULTIVATION IN THE UNITED STATES.

Wayne County, N. Y., in 1816, was the first locality in this country to distill peppermint on a commercial scale. The supply of root-stocks was obtained from the wild plants found growing along the banks of streams and brooks. Adjacent counties soon undertook the cultivation of peppermint, but Wayne County was then, and is now, the principal peppermint district in New York.

The cultivation of peppermint was extended to Ashtabula, Geauga, and Cuyahoga counties in Ohio, and also to northern Indiana. Roots were taken from Ohio into St. Joseph County, Mich., the first plantation being made on Pigeon prairie in 1835. Other plantations in St. Joseph County were established the following years, and adjoining counties soon took up the cultivation of peppermint, and southwestern Michigan has been for thirty-five years or more the greatest peppermint-producing section in the United States.

About 1844 an interesting peppermint-oil monopoly[a] was undertaken by a New York firm, which seems to have put an end to peppermint cultivation in Ohio, for none of the counties just mentioned has since been heard from as a peppermint-producing section.

The first step taken by this New York firm in its efforts to control the peppermint-oil market was to send a representative to Liverpool, England, to ascertain the amount annually demanded by that market, which was found to be about 12,000 pounds. This done, another agent was sent West to determine the amount produced annually, with the result that it was found that the farms in New York did not produce enough oil for their purposes, the plantations in Ohio too much, while those in Michigan seemed to produce just about the right amount to satisfy the Liverpool demand. A contract was then entered into by this agent with the producers in New York and Ohio "whereby he bound them under heavy penalties to plow up their mint fields and destroy the roots, and not plant any more mint, or sell or give away any roots, or produce or sell any mint oil for the

[a] Proc. Amer. Pharm. Assoc., 7: 449–459 (1858).

period of five years." For this wholesale destruction of their mint fields the producers received a bonus of $1.50 per acre. Next a contract was made by the agent with the producers of St. Joseph County, Mich., agreeing to pay them $2.50 a pound for their mint oil, every ounce of the mint oil to be delivered for a period of five years to the agents named in the contract. They also were prohibited during this period from extending their plantations and from selling roots to anyone. The producers held to these contracts for about three years, after which period the New York firm was not so anxious to enforce them, having, in the meantime, acquired a large fortune through its peppermint-oil monopoly.

Since that period the area devoted to peppermint cultivation in Michigan has steadily increased, and northern Indiana, with its principal centers of production in St. Joseph, Steuben, and La Grange counties, continues to place on the market a considerable quantity of oil. Ohio seems to have abandoned peppermint cultivation, at least on a commercial scale, and New York, for a number of years and until very recently, had greatly reduced the area under peppermint, thousands of acres formerly devoted to this crop having been given over to sugar beets, onions, and celery. In 1889 Wayne County, N. Y., had 3,325 acres of peppermint, whereas in 1899 there were only 300 acres. In 1905, about 933 acres were under cultivation.

Special canvassers appointed by the State of Michigan [a] made a canvass of 299 growers in the peppermint district in that State, covering 39 townships in nine counties (Allegan, Berrien, Branch, Cass, Kalamazoo, Oakland, St. Joseph, St. Clair, and Van Buren), and the total number of acres under peppermint cultivation, the number of pounds of oil distilled, and the average number of pounds per acre, as ascertained by this canvass, for the years 1900, 1901, and 1902, are as follows:

Items.	1900.	1901.	1902.
Total number of acres grown	2,112	2,782½	6,400½
Total number of pounds distilled	47,628½	63,718½	82,420½
Average number of pounds per acre	22.5	23.9	12.8

CULTIVATION.

Peppermint cultivation is most profitable on muck lands, such as are now used in Michigan for this crop and for celery and cranberry culture. These muck lands were formerly marshes and swamps, which have been reclaimed by draining, plowing, and cultivating, the swamp vegetation having been thus subdued, and the decayed

[a] Twentieth Annual Report of the Bureau of Labor of the State of Michigan, 1903, pp. 438–447.

vegetable matter resulting in a very black soil which is most admirably adapted to mint cultivation. Formerly peppermint was grown exclusively on upland soil in Michigan, but it is a very exhausting crop on such land. Only two crops can be obtained from upland plantations, and after the second year's harvest the land is plowed and a rotation of clover, corn, etc., is practiced for five years before peppermint is again planted. But on the rich muck land peppermint can be grown year after year for six or seven years, the land being plowed up after each crop is harvested, and the runners turned under to form a new growth the succeeding year. The ground is harrowed in autumn and again in spring, and carefully weeded. Peppermint will grow, however, on any land that will produce good crops of corn, the ground being prepared by deep plowing and harrowing.

In Michigan[a] the land is plowed in the autumn, and early in spring it is harrowed and marked with furrows about 3 feet apart. The roots selected for planting are from one-eighth to one-quarter of an inch thick, and from 1 to 3 feet long; and the workmen engaged in "setting mint," as the process is called, carry these roots in sacks across their shoulders and place them in the furrows by hand, covering the roots with one foot and stepping on them with the other. The roots are planted so close together in the furrow as to form a continuous line. An expert workman can plant about an acre in a day.

In about two weeks the young plants will make their appearance, and are carefully hoed and cultivated until July and August, when the plants have usually sent out so many runners as to make further cultivation difficult. The crop is cultivated with horse cultivators, but if the land was very weedy in the first place, the weeds will have to be pulled by hand. It is very necessary that the land be free from weeds, as any collected with the peppermint crop will seriously injure the quality of the oil.

It may be interesting to note here that on muck lands, when necessary, the horses are usually provided with mud shoes to prevent their sinking into the soft, wet ground, these mud shoes consisting of wide pieces of iron or wood about 9 by 10 inches, fastened to the hoofs and ordinary shoes by means of bolts and straps.

CONDITIONS INJURIOUS TO CROP.

Cold and wet weather or extremely dry periods have a very unfavorable effect on the mint crop. Insect enemies also tend to cut down the mint harvest—grasshoppers, crickets, and cutworms sometimes doing considerable damage. A rust, causing the foliage to drop off

[a] Twentieth Annual Report of the Bureau of Labor of the State of Michigan, 1903, pp. 438–447.

and leaving the stems almost bare, is apt to follow if very moist weather occurs toward the latter part of the season. Weeds are especially to be avoided in a mint field, since, as stated, the quality of the oil will be seriously impaired if these are harvested with the peppermint. The weeds generally found in a peppermint field are Canada fleabane (*Leptilon canadense*), fireweed (*Erechtites hieracifolia*), giant ragweed (*Ambrosia trifida*), pennyroyal (*Hedeoma pulegioides*), Eaton's grass (*Eatonia pennsylvanica*), June grass (*Poa pratensis*), and other low grasses.

HARVESTING AND DISTILLATION.

The first crop of mint is harvested in the latter part of August, when the plants are in full flower, and the gathering continues until about the middle of September, the stills running night and day until all the mint is disposed of. The first crop is usually cut with a scythe, as mowing machines do not work well on soft cultivated land. The succeeding crops are cut with a mowing machine or sweep-rake reaper. The highest yield per acre and the best quality of oil are obtained from the first year's crop. Sometimes, if the weather conditions have been very favorable, a second cutting is made. The yield of oil from peppermint obtained from the same field sometimes varies very much, the condition of the atmosphere seeming to exert an influence upon it, as it is said that mint cut after a warm and humid night will yield more oil than that cut after a cool and dry night. It requires about 330 pounds of dried peppermint to produce 1 pound of oil, and the yield of oil from an acre ranges from 12 to 50 pounds.

If the mint crop has been grown on muck land, all that is necessary after the crop has been harvested is to plow up the land and turn the runners under for a new crop. If grown on upland, after the second year's crop is in, or, at the most, after the third year's harvest, the land is plowed and then given up to other crops. Peppermint exhausts the land, and it is necessary to practice rotation of crops for about five years in order to put the land in condition if it is desired to use it again for peppermint cultivation.

After the plants are cut they are usually placed in windrows until they are dried, but are not allowed to become so dry as to permit the leaves to shatter off, and are then taken to the distillery. Some growers believe that if the plants are allowed to dry there will be a smaller oil content owing to the escape of some of the oil into the atmosphere, and so have the plants brought to the distillery in the green state; but Mr. A. M. Todd[a] is of the opinion that no loss of oil will result

[a] Amer. Jour. Pharm., 60: 328–332 (1888).

from drying, his experiments along this line showing that the dry plants can be distilled three times as rapidly as the green plants, and that a larger quantity of oil may be obtained. He states that—

> To obtain the best results, both as to quality of essential oil and economy of transportation and distillation, the plants should be dried as thoroughly as possible without endangering the loss of the leaves in handling. Distillation should then take place as soon as convenient to prevent the oxidation of the oil in the leaf by atmospheric action.

The smaller producers, who have no stills of their own, have their mint crop hauled to the nearest peppermint distillery, where it is distilled for them at a cost of 25 cents per pound of oil.

DESCRIPTION OF STILL.

The apparatus used in peppermint distillation in the early years of the industry in this country consisted of a copper kettle, from the top of which a pipe connected with a condensing "worm." Water was placed in the kettle and the plants were immersed in it, and direct heat was applied to the bottom from a furnace. With such a still only about 15 pounds of oil could be obtained from a charge. In 1846, large wooden vats were substituted for the copper kettles, and the plants were distilled by steam passing through them. The kettle formerly used as the still was now employed to generate steam, a long pipe conveying the steam to the bottom of the vats. With this method of distillation from 75 to 100 pounds of oil could be obtained from a charge without much additional expense.

A modern peppermint still (fig. 3) may be briefly described as follows: The apparatus required consists of a boiler, a pair of large circular wooden vats, a condenser, and a receiver. The boiler, of course, is used for the generation of steam.

Two wooden vats are used in order that they may be filled and emptied alternately. These vats are about 6 feet high and about 5 feet in diameter, with tight-fitting removable covers and perforated false bottoms. Steam pipes are led from the boiler into the bottom of the vats.

The condenser consists of a series of pipes of block tin, either immersed in tanks of cold water or over which cold water is kept running, the condenser being connected with the top of the distilling vats. The condensed steam, together with the oil, flows into a metallic receiver, in which the oil, being lighter than the water, rises to the top and can be drawn off.

The perforated false bottoms with which the vats are supplied permit the passage of steam. A strong iron hoop is placed about this false bottom, and two pairs of stout chains, which meet at the top

of the vat in a pair of rings, are attached to it. After the charge has been distilled it is drawn from the vats by means of this arrangement.

The plants are thrown into the vats and are closely packed by two or three men tramping upon them, and as the vat becomes about one-third full the packing is still further assisted by turning in a small supply of steam, which softens the plants. When the vat is filled the tight cover is replaced and a full head of steam turned on. In the largest distilleries the vats have a capacity of from 2,000 to 3,000 pounds of dried plants each.

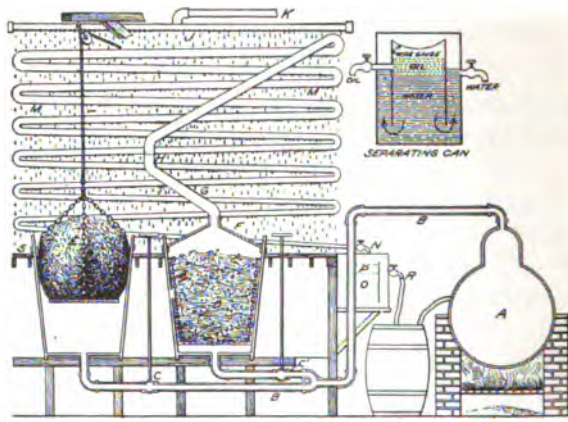

FIG. 3.—Peppermint still. (After Dewey, in Bailey's Cyclopedia of American Horticulture.)

A, boiler; *B*, steam pipes leading to vats; *C*, valves for shutting off steam; *D*, mint packed in vat ready for distilling; *E*, mint being lowered into vat; *F*, tight-fitting cover used alternately for both vats; *G*, pipe from top of vat, joined at *H* so as to swing to other vat; *J*, perforated pipe, from which cold water drops over condensing tubes; *K*, supply pipe for cold water; *M*, condensing pipes; *N*, outlet for condensed oil and water; *O* and *P*, water and oil in separating can; *R*, outlet for water; *S*, floor of distilling room.

Large tanks are used for storing the oil, and cans holding 20 pounds each are employed for shipping, three of these cans being placed in a wooden case.

The peppermint hay which remains after distillation is used as a fertilizer or is fed to stock.

PEPPERMINT OIL AND MENTHOL.

Peppermint leaves and flowering tops are official in the Eighth Decennial Revision of the United States Pharmacopœia, as are likewise the following products and preparations derived from these parts: Oil of peppermint, menthol, spirit of peppermint, and peppermint water.

The United States Pharmacopœia describes oil of peppermint as "a colorless liquid, having the characteristic strong odor of peppermint and a strongly aromatic pungent taste, followed by a sensation of cold when air is drawn into the mouth." It is largely used in medicine, internally as a stimulant and carminative, and externally to relieve neuralgic and rheumatic conditions. It is also used for flavoring and scenting confectionery, cordials, and cosmetics. There is a slight difference in the odor of white and black peppermint oil, the black being more pungent and less agreeable in fragrance than the white, which has a much finer odor, but, as already indicated, the white mint is less hardy than the black and yields a smaller quantity of oil.

The Japanese oil of peppermint, which, as pointed out elsewhere in these pages, is obtained from a different species of mint than that which produces the true oil of peppermint, is very inferior to the last named. It has a very unpleasant odor and a bitter, disagreeable taste, but it is a heavy oil and contains a higher percentage of menthol and, being a very much cheaper oil, it is liable to be used as an adulterant of true peppermint oil.

Menthol, formerly known as peppermint camphor, is the solid constituent of oil of peppermint, obtained by subjecting the distilled oil to an exceedingly low temperature by means of a freezing mixture. Its properties are about the same as those of oil of peppermint, only somewhat intensified. It is very largely made up into cones or pencils, which furnish a popular remedy, to be applied externally or inhaled, for the relief of headache, neuralgia, catarrh, asthma, and kindred affections. It is also largely employed in other forms of medication. The name "pipmenthol" has been applied to the menthol obtained from the American oil, to distinguish it from the Japanese menthol. Pipmenthol is said to have a distinct odor of peppermint, while the Japanese menthol has but a slight peppermint odor.

EXPORT OF PEPPERMINT OIL.

The exports of peppermint oil during the fiscal year ended June 30, 1904, amounted to 42,939 pounds, valued at $124,728. Germany and the United Kingdom were the largest consumers, the former receiving 22,372 pounds, valued at $65,505, and the latter 11,558 pounds, worth $31,798.

The following tables show the export of peppermint oil, by countries, for the fiscal year ended June 30, 1904, and the quantities and values of peppermint oil exported for a period of ten years, from July 1, 1894, to June 30, 1904, inclusive:

Exports of peppermint oil, by countries, for the fiscal year ended June 30, 1904.[a]

Country.	Quantity.	Value.
	Pounds.	
Belgium	473	$1,585
France	3,054	10,059
Germany	22,372	65,505
Italy	826	2,471
Netherlands	590	1,934
United Kingdom	11,558	31,798
Dominion of Canada:		
Nova Scotia, New Brunswick, etc	85	234
Quebec, Ontario, Manitoba, etc	1,165	3,306
Newfoundland and Labrador	94	204
West Indies:		
British	183	700
Cuba	29	87
Danish	17	55
Dutch	20	61
Argentina	1,237	3,504
British Guiana	10	31
Peru	50	175
British Australasia	1,176	3,019
Total	42,939	124,728

[a] The Foreign Commerce and Navigation of the United States for the year ending June 30, 1904, vol. 1, p. 531, Bureau of Statistics, Department of Commerce and Labor.

Quantities and values of peppermint oil exported during the fiscal years 1895 to 1904, inclusive.[a]

Fiscal year.	Quantity.	Value.	Fiscal year.	Quantity.	Value.
	Pounds.			*Pounds.*	
1895	87,633	$194,616	1900	89,558	$90,298
1896	85,290	174,810	1901	60,166	63,672
1897	162,492	257,484	1902	36,801	54,898
1898	145,375	180,811	1903	13,083	34,943
1899	117,462	118,227	1904	42,939	124,728

[a] From The Foreign Commerce and Navigation of the United States for the year ending June 30, 1902, vol. 2, p. 309, Bureau of Statistics, Treasury Department; and The Foreign Commerce and Navigation of the United States for the year ending June 30, 1904, vol. 1, p. 192, Bureau of Statistics, Department of Commerce and Labor.

PRICES OF PEPPERMINT OIL.

The price of peppermint oil was very low for a few years prior to 1900, the enormous production of 1897 resulting in a great drop in price. The lowest price paid for it was in 1899, when it brought only 75 cents per pound. As a result of the low price a great many mint farmers restricted the area of their mint plantations or altogether abandoned peppermint cultivation. The smaller output of the following seasons again sent prices up, and in 1902 the oil sold as high as $4.75 a pound, which price was maintained until early in 1903, when it gradually declined, until toward the end of that year it reached $2.20 per pound.

The following table[a] gives the highest and lowest prices of peppermint oil in bulk from 1873 to September 16, 1905:

Year.	Highest.	Lowest.	Year.	Highest.	Lowest.	Year.	Highest.	Lowest.
1873	$3.15	$3.15	1884	$3.00	$2.50	1895	$2.00	$1.70
1874	5.25	3.75	1885	4.37	2.75	1896	1.85	1.20
1875	5.50	3.20	1886	3.60	2.75	1897	1.25	.90
1876	3.75	2.40	1887	2.75	1.90	1898	.90	.80
1877	3.00	1.75	1888	2.40	1.75	1899	.90	.75
1878	2.00	1.50	1889	2.30	1.80	1900	1.10	.80
1879	2.65	1.45	1890	2.40	1.80	1901	1.80	1.10
1880	2.87	2.60	1891	2.50	2.45	1902	4.75	1.70
1881	2.85	2.35	1892	2.50	2.15	1903	4.75	2.20
1882	2.50	2.25	1893	2.45	2.15	1904	3.75	2.65
1883	2.60	2.20	1894	2.45	1.70	1905*	3.45	2.25

* To September 16.

The good prices of the past few years have caused many farmers to look again to peppermint as a profitable crop, as noted in increased areas under cultivation in many localities. This is the case not only in Michigan and Indiana, but also in New York, where for many years the peppermint industry has been declining. Thus, if favorable conditions of growth prevail, an increased production may be looked for within the next few years, which will have the effect of again depressing prices.

As is the case with other products the prices of which are subject to great fluctuations, the condition of the market for peppermint oil needs to be closely observed. The cost of cultivation per acre has been stated at from $12 to $14, and, with a charge of 25 cents per pound of oil for distillation, the market price may easily fall below the cost of production.

[a] From Oil, Paint, and Drug Reporter, September 18, 1905, p. 7.

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IV.—THE POISONOUS ACTION OF JOHNSON GRASS.[a]

By A. C. Crawford, *Pharmacologist, Poisonous-Plant Investigations.*

Johnson grass, which was introduced from Turkey into this country about 1830,[b] has spread so that in many places it is considered as a weed and pest.[c] Some farmers, however, have utilized the dried grass as hay with advantage, either alone or combined with other food material,[d] and chemical analyses have proved its value as feed. Recently reports have come to this office from California of the death of cattle under such circumstances as to point to Johnson grass as the causative agent—the cattle dying in thirty minutes after eating the grass. Johnson grass belongs to the same genus of the Gramineae as sorghum. This group has been partially investigated chemically, and it has been found that the fresh green plants of various members yield

[a] This office has from time to time received communications from stockmen, especially in the lower part of California, Arizona, and adjacent territory, expressing a suspicion that the eating of Johnson grass had caused the death of stock with rather sudden and violent symptoms. There has seemed to be little ground in poisonous-plant literature to support such an explanation. Last summer, however, convincing observations were reported from California by a stockman who had lost heavily, and a supply of the grass in question was obtained. The result of the study of this material was so positive, and the possibility of damage due to this unsuspected forage plant so clear, that this preliminary notice is put out in the hope of getting observations and material for study from many sources, in order, if possible, to determine the conditions under which the poisonous properties are developed and over how wide an area they are likely to appear.

Rodney H. True, *Physiologist.*

Office of Poisonous-Plant Investigations,
Washington, D. C., December 11, 1905.

[b] Ball, C. R. Johnson Grass. Bul. No. 11, Bureau of Plant Industry, United States Department of Agriculture, 1902.

[c] Spillman, W. J. Extermination of Johnson Grass. Bul. No. 72, Part III, Bureau of Plant Industry, United States Department of Agriculture, 1905.

[d] North Carolina Agricultural Experiment Station, Bul. 97, p. 92; Vasey, G., Grasses of the South, Bul. No. 3, Division of Botany, United States Department of Agriculture, 1887; Report of the Commissioner of Agriculture for 1881, pp. 231, 232, 239, 241; Report of the Secretary of Agriculture, 1890, p. 381.

hydrocyanic acid as a result of the action of enzymes on more highly complex bodies.[a]

Ball[b] in 1902 stated that at that time there had been no official reports to his office of cases of poisoning by Johnson grass, but that there were some newspaper statements to that effect. He thought these accounts were probably not authentic, but stated that "since Johnson grass is closely related to sorghum, which is known to be poisonous under some circumstances, it would not be surprising if Johnson grass should also be poisonous under like conditions. * * * In comparison with the great number of cattle fed or pastured in Johnson grass, the reported cases of poisoning are extremely rare."

The first report of the poisonous action of Johnson grass which reached the Department came from Miles City, Mont. Mr. William Story reported that he and a neighbor had lost several head of cattle after they had eaten small quantities of the grass, and that they had died very suddenly. Mr. Story suggested that there was "something peculiarly poisonous about the grass." The Commissioner of Agriculture in publishing this report stated that "although the grass has been cultivated in the South for forty or fifty years, no similar charges have been made against it."[c]

In India this plant is widely used as a fodder for cattle,[d] and the natives make use of the seeds for food. It has been noted there that deaths in cattle frequently occur when, on account of the failure of rain, the plants which have reached a certain size become stunted and withered. The toxic principle appears simultaneously over a wide area, but soon disappears if a rainfall occurs.[e] The deaths of cattle have been attributed by some to an insect living upon the plant, and in Australia it is the belief that *Sorghum vulgare*, which also yields hydrocyanic acid, becomes more poisonous when attacked by an insect during a drought. A similar observation has been made with *Sorghum vulgare* in the Sudan. Balfour[f] found that one specimen of the plant which harbored aphids yielded more hydrocyanic acid than a

[a] Dunstan, W. R., and Henry, T. A., The Nature and Origin of the Poison of Lotus Arabicus, Phil. Trans. Roy. Soc. London, 1901, vol. 194, B., p. 515; Dunstan, W. R., and Henry, T. A., Cyanogenesis in Plants, Phil. Trans. Roy. Soc. London, 1902, vol. 199, A., p. 399; Slade, Henry B., Prussic Acid in Sorghum, Jour. Amer. Chem. Soc., 1903, vol. 25, pp. 55–59; Slade, Henry B., Study of the Enzymes of Green Sorghum, Fifteenth Annual Report, Agricultural Experiment Station of Nebraska, 1902, pp. 55–62; Brünnich, J. C., Hydrocyanic Acid in Fodder-plants, Jour. Chem. Soc., 1903, vol. 83, part 2, pp. 788–796.

[b] Bul. No. 11, Bureau of Plant Industry, United States Department of Agriculture, p. 23.

[c] Report of the Commissioner of Agriculture, 1885, p. 74.

[d] Duthie, J. F. Fodder Grasses of Northern India, 1888, p. 41.

[e] Pease, H. T. Poisoning of Cattle by Andropogon Sorghum. Jour. Compar. Med. and Vet. Arch., vol. 18, 1897, p. 679. See also Agr. Ledger, 1896, No. 24.

[f] Balfour, Andrew. Cyanogenesis in Sorghum Vulgare. First Report, Wellcome Research Laboratory, at Gordon Mem. College, Khartum, 1904, p. 47.

second one without parasites. Pease has lately claimed that the deaths from Johnson grass in India were really cases of nitrate poisoning, as he found 25 per cent of nitrate of potassium in the stem of the plant and was able to produce somewhat similar symptoms in animals by feeding them this salt. Johnson grass is being introduced into Australia as a fodder plant, but as yet no reports of its poisonous action there have been noted by the writer.[a]

There has been some chemical study of Johnson grass, but not with reference to any poisonous principle.[b]

A fresh, green, mature, nonflowering specimen of Johnson grass, moistened with a little water and preserved with chloroform, was sent from Santa Rosa, Cal., in sealed glass vessels, to this laboratory. This was botanically identified here as Johnson grass. This specimen was not immediately worked up, but remained in the jars for about a month. At that time on opening the jars a marked odor of hydrocyanic acid, together with that of chloroform, was detected. The ground-up plant, with the water in which it came, was distilled, and the distillate was caught in sodium hydrate solution. This distillate, on mixing with ferrous sulphate and acidulation with hydrochloric acid, gave a heavy blue precipitate with ferric chlorid. Yellow ammonium sulphid was added to the same filtrate, and the mixture was evaporated to dryness on the bath. The dried residue was then taken in hydrochloric acid water, and on the addition of ferric chlorid the fluid gave the characteristic red reaction for hydrocyanic acid. The nitro-prussid, picric acid, and silver nitrate reactions were all positive for hydrocyanic acid. The aqueous fluid in which the plant was shipped was filtered off from the plant and gave on distillation all the above reactions for hydrocyanic acid.

According to our California correspondent, this plant is poisonous when grown on irrigated as well as on nonirrigated lands, but especially so when grown on irrigated soil and the growth has become rank.

Recently Dunstan[c] has shown that lima beans (*Phaseolus lunatus*), which when grown wild in Mauritius yield sufficient hydrocyanic acid to produce poisoning, when cultivated in Burma lose this toxicity almost entirely, although it may return most unexpectedly.[d] He was unable, however, to determine the condition which increased its poisonous properties.

It is interesting to note, besides this production of hydrocyanic acid from complex glucosids, that proteids, when subjected to oxidation

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[a] Maiden, J. H. Useful Australian Plants. Department of Agriculture New South Wales, Misc. Pub. No. 22, 1896.

[b] Annual Report of the Commissioner of Agriculture, 1878, p. 168.

[c] Dunstan, W. R. Phaseolus Lunatus. Agricultural Ledger, 1905, No. 2.

[d] Church, A. H., Food-Grains of India, 1886, p. 155; Watt, George, Dictionary of the Economic Products of India, vol. 6, part I, 1892, p. 187.

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under certain conditions, also yield it.[a] In fact, hydrocyanic acid may exist in plants in two forms, either as the acid or as one of its salts, or in the form of complex glucosids.[b] Under the circumstances, the conclusions of Brünnich[c] should be held in mind, viz, that "all fodder plants related to sorghum must be used with discretion in either the green or the dried state, and should not be given in large amounts to animals which have fasted for some time."

In reference to other forage plants, Avery[d] says that "Kafir-corn leaves also contain this poison, but other forage plants—clover, alfalfa, grasses, and corn—give no test for prussic acid," and Brünnich also found it in Guinea grass or *Panicum maximum* and *P. muticum*. Many facts have been collected relative to the distribution of hydrocyanic acid in plants, yet its exact significance in their metabolism is unknown.[e] The question as to the relationship of parasites[f] to the production of hydrocyanic acid remains to be solved.

Later investigations will be carried on to determine the nature of this cyanogenetic compound, to determine whether hydrocyanic acid is present in all stages of its growth, but disappears on drying the plant, whether the hydrocyanic acid production occurs under all conditions or only when grown on certain soils, and the amount produced. Hydrocyanic acid will also be looked for in other members of this genus.

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[a] Plummer, R. H. A. The Formation of Prussic Acid by the Oxidation of Albumins. Jour. Physiol., vol. 31, 1904, p. 65; vol. 32, 1904, p. 50.

[b] Les Nouveaux Remèdes, vol. 14, 1898, p. 272.

[c] Jour. Chem. Soc., 1903, vol. 83, part 2, p. 792.

[d] Avery, S. Laboratory Notes on Poison in Sorghum. Jour. Compar. Med. and Vet. Arch., vol. 23, 1902, p. 705.

[e] Czapek, F. Biochemie d. Pflanzen, 1905, vol. 2, p. 259.

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FIG. 1.—CONNECTICUT CUBAN TOBACCO, FIRST YEAR FROM CUBA.

FIG. 2.—THE SAME FIELD SHOWN IN FIGURE 1, AFTER SAVING SEED UNDER BAG AND THE SELECTION OF THE BEST PLANTS FOR TWO YEARS.

THE PHILADELPHIA
MAR 17 1906
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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY— BULLETIN NO. 91.

B. T. GALLOWAY, *Chief of Bureau.*

VARIETIES OF TOBACCO SEED DISTRIBUTED IN 1905-6, WITH CULTURAL DIRECTIONS.

BY

A. D. SHAMEL AND W. W. COBEY,

IN CHARGE OF TOBACCO BREEDING EXPERIMENTS, LABORATORY OF PLANT BREEDING.

SEED AND PLANT INTRODUCTION AND DISTRIBUTION.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., December 11, 1905.

SIR: I have the honor to transmit herewith a paper entitled "Varieties of Tobacco Seed Distributed in 1905–6, with Cultural Directions," and respectfully recommend that it be published as Bulletin No. 91 of the series of this Bureau.

This paper was prepared by Messrs. A. D. Shamel and W. W. Cobey, in charge of tobacco breeding experiments, Laboratory of Plant Breeding, and it has been submitted by the Botanist in Charge of Seed and Plant Introduction and Distribution with a view to publication.

The illustrations which accompany this paper are considered essential to a full understanding of the text.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

PREFACE.

Following the established policy of this office of improving the methods of distributing seed wherever possible, a departure has this year been made in the handling of the tobacco-seed distribution, the work of selecting the types which it is desired to distribute being undertaken by the tobacco experts of the Laboratory of Plant Breeding of the Bureau of Plant Industry. This, it is believed, will result in placing in the hands of really interested persons the very best seed of the various types of tobacco. Some of these types will be entirely new, the results of selection and breeding by Messrs. Shamel and Cobey during the past two or three years. Other types will be such as are already established, but the seed distributed this year has all been carefully selected with reference to securing the best possible strain of each type.

Special attention has been paid in the present bulletin to a discussion of the methods of growing and handling certain varieties, especially those that are more highly specialized. This course was considered necessary, because even if good tobacco is grown it is easily spoiled by improper handling. It is hoped that those who read these pages will pay special attention also to the discussion of the selection of seed, because the permanent improvement of tobacco types must necessarily be left in the hands of intelligent cultivators, and if careful selection is not practiced by them the work which the Department of Agriculture is doing will fail to attain the full measure of success which would otherwise be possible.

A. J. PIETERS,
Botanist in Charge.

OFFICE OF SEED AND PLANT
INTRODUCTION AND DISTRIBUTION,
Washington, D. C., December 11, 1905.

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VARIETIES OF TOBACCO SEED DISTRIBUTED IN 1905-6, WITH CULTURAL DIRECTIONS.

INTRODUCTION.

In the distribution of tobacco seed by the Department of Agriculture small samples of seed of improved native and standard foreign-grown varieties are furnished for experimental purposes. The object of this distribution in regions where tobacco is not grown at present is to enable farmers to make a reliable test of the adaptability of their conditions of soil and climate to tobacco culture. In the established tobacco-growing sections the growers may secure improved varieties by testing the seed, sent out in this distribution, adapted to the conditions of culture and purposes of manufacture for which the tobacco is grown. The Havana seed tobacco of the Connecticut Valley and the Florida Sumatra type of the southern Georgia and western Florida districts are striking illustrations of the beneficial results of the introduction of new varieties or the importation of standard foreign-grown tobaccos.

Many illustrations might be cited of the importance of testing different varieties of tobacco in the established tobacco-growing sections, and it is the object of this distribution to furnish tobacco growers carefully selected seed of improved strains of standard varieties of tobacco, in order that they may obtain the best types of tobacco adapted to their conditions of soil and climate.

In all cases where foreign-grown or improved native varieties have been successfully established in any region, small crops have been grown until the strains have become adapted to local conditions of climate and soil and a uniform type has been secured by continued and systematic selection of seed.

In the distribution of tobacco seed this season, unless a particular variety of tobacco is requested by the growers an attempt will be made to send the variety of tobacco which experience has shown to be most nearly adapted to the conditions under which the tobacco is to be grown. It has been found by experience that an attempt to produce a tobacco on a soil not suited to the type planted will in most cases

result in failure, from the fact that the tobacco produced is unfit for the same grade as the parent plants and will not meet the requirements of an established class of tobacco, but must sell as a nondescript. In some cases, however, new types of tobacco have been established in this way which have proved of sufficient importance to create a market on their own merit, and wherever it seems possible that such results may be secured the seed of highly bred new varieties will be sent to the particular section adapted to the growth of these types.

The tobacco plant readily adapts itself to a great variety of conditions, but is easily affected by the chemical and mechanical conditions of the soil. In fact, it has been found that the relation of the physical conditions of the soil to the texture and quality of the leaf has become so well established that it is possible to determine in a general way by a study of the soil and climate the adaptability of the different sections to a particular type and class of tobacco. The climatic conditions largely influence the quality and aroma in the same way that the soil influences the texture of the tobacco leaf. In a warm climate the tendency is to produce a leaf with a large amount of gum and an aromatic tobacco; in northern sections the leaf becomes larger and finer, but is lacking in aroma. However, these tendencies may be modified in different sections by excessive rainfall, which usually causes a thin leaf and lack of aroma.

As a rule, tobacco which is grown near the sea has poor combustibility, which is supposed to be due to the action of the chlorin in the salt of the sea air. As a general rule, tropical climates produce the best tobaccos for cigar fillers, and temperate climates produce tobaccos which are best adapted for cigar wrappers. In the warmer sections of temperate climates the best smoking and chewing tobaccos are produced.

It has been definitely determined by experiments conducted by the Bureau of Plant Industry that the different types of tobacco can be greatly improved by seed selection and breeding. Inasmuch as the tobacco plant produces a large quantity of seed, it is possible by saving comparatively few plants to furnish enough highly bred seed for the planting of a large area. It is important that where new strains or varieties of tobacco are tested by the growers a small number of plants be grown the first year, in order to test the adaptability of these tobaccos to the local conditions. If the variety proves to be of value the grower can select the best of the individual plants in this small field for the seed of his entire crop the succeeding year.

The importance of growing a small crop from imported or newly introduced seed is illustrated in Plate I. In figure 1 is shown a field in the Connecticut Valley in the season of 1903, grown from freshly imported Cuban seed. It can be seen that in this field there are a large number of "freak," branching, narrow-leaved, and other unde-

sirable types of tobacco for cigar-wrapper purposes. The number of freak plants in this field amounted to one-third the total number of plants and caused the grower a great loss. Specially good plants, free from suckering, were selected for seed in this field, and the seed saved under bag. The crop the following season raised from this seed was comparatively free from freaks and undesirable plants. In 1905 the crop shown in figure 2 from seed saved from the preceding year's selected seed plants of this same variety on the same field was remarkably uniform in type, every plant being like every other plant in the field. A casual inspection of the two figures will show that two years' systematic seed selection, saving the seed under bag, has served to weed out all of the freak and undesirable types and has enabled the grower to produce a uniform field of a highly desirable type of tobacco.

There is no general farm crop which responds so readily to seed selection and breeding as tobacco. The transmitting power of the individual parent plants is exceedingly strong, and the progeny of the individual seed plants show great uniformity when seed is saved under bag according to the plan outlined in the following pages.

It is exceedingly important that strains of tobacco be secured in different sections resistant to the "root knot," "root wilt," and other fungous diseases which attack the tobacco crop. In the experiments conducted by the Bureau of Plant Industry it has been found that by saving the seed of resistant plants under bag it is possible to produce uniform strains which are immune to the attack of most root diseases. Wherever possible the Department will undertake to make selections of resistant types and furnish small quantities of this seed for distribution.

It is advisable for tobacco growers to secure and test new varieties in different sections, and especially to secure hybrids of the native with the imported varieties. In order to safely introduce these hybrids it is essential to grow a few plants of the desired imported variety in order to procure pollen for crossing. In no instance should a large area of plants be grown from the first year's cross or from the imported seed. One hundred plants of each type or variety will give a fair indication of the nature and value of the cross or importation, and will furnish sufficient plants for seed selection for the next year's crop. After the grower secures a uniform crop of the desired kind sufficient seed may be saved for future crops in accordance with the directions given in this bulletin.

DESCRIPTION OF VARIETIES.

It is impossible to recommend the best variety of tobacco for growing in a new region, that being a matter which can only be determined by careful experiments. If the soil and climatic conditions are known, a study of the description of the varieties sent out in this distribution will enable the grower to select a variety which will be adapted most

nearly to the new conditions. In the following list the best varieties for testing by the growers are grouped with reference to their uses and the character of soil which produces the best yield of each variety, as determined by past experience.

CIGAR-WRAPPER TOBACCOS.

Sumatra.—Used wholly for the production of high-grade cigar wrappers and not considered of any value for fillers. In the United States this variety is grown under slat or cloth shade. Adapted to sandy loam soil. In western Florida, where it is grown extensively, the surface soil is underlaid by a red clay subsoil. The leaves are very thin, of fine texture, with small veins, and vary from 12 to 20 inches in length and 8 to 16 inches in width. The plants bear from 16 to 30 leaves, with comparatively long internodes. The leaves have an erect habit of growth. Under favorable conditions for growth the plants reach a height of from 7 to 9 feet. This variety produces the best grade of domestic cigar wrappers.

Grown in western Florida, in southern Georgia, and in the Connecticut Valley.

Connecticut Havana.—Used for cigar wrappers and binders, and the top leaves are frequently used for fillers in the inferior grades of domestic cigars. Adapted to light alluvial, sandy soils, containing a small percentage of clay, and as a rule the less the clay the higher the yield of fine cigar wrappers. Where this variety is grown for fillers a rich clay yielding a heavy crop of leaf is probably the most desirable type of soil. The leaves are thin, of fine texture and delicate flavor, set very close together on the stalk, with very short internodes, and have a very erect habit of growth. The plants bear from 10 to 15 leaves, varying in average length from 20 to 32 inches and in average width of from 10 to 15 inches. This variety was secured by continued seed selection from crops grown from seed imported from Cuba, and is probably a cross between these Cuban plants and the native Broadleaf of the Connecticut Valley.

Grown in the Connecticut Valley, Wisconsin (mainly for binders), Ohio, Pennsylvania, and New York. One of the best general-purpose tobaccos.

Connecticut Broadleaf.—Formerly known and generally recognized in the trade as Seedleaf. Used for cigar wrappers and binders, and the lower grades, to a limited extent, for blending with other tobaccos for cigar fillers. Adapted to sandy loam soil. This variety makes an exceedingly rapid growth. The leaves are very broad, sweet tasting, thin, elastic, silky, and with small veins. The leaves are set very close together on the plant, having a very characteristic drooping habit of growth, and vary in length from 24 to 36 inches and in width from 12 to 22 inches. The size of leaf varies greatly in different sections

and with the different strains which have been developed by individual growers. The seed of this variety has been sent to many sections of the United States and a large number of important varieties have been secured from this source, as in the case of the Ohio Seedleaf, which can be traced directly to Connecticut Broadleaf seed.

Grown in the Connecticut Valley, New Hampshire, Vermont, New York, Pennsylvania, Ohio, Wisconsin Minnesota, and to a slight extent in Indiana and Illinois.

CIGAR-FILLER TOBACCOS.

Cuban.—Used for high-grade cigar wrappers when grown under shade, but is generally grown outside for cigar fillers. Adapted to alluvial or sandy soil resting on red clay subsoil. This variety has a small leaf of fine texture. The leaves are short and round, with small veins, medium to heavy body, varying from 10 to 18 inches in length, and 6 to 14 inches in width. When this variety is taken north the influence of the climate and soil conditions tends to promote the development of a large leaf at the expense of fineness of texture and quality. When grown from freshly imported seed in southern tobacco districts the tobacco seems to retain the valuable qualities of flavor, aroma, smooth taste, and other characters of the imported Cuban tobacco. Whether these qualities can be retained by continued selection of seed from desirable plants is a subject for experimentation, but the evidence obtained up to this time indicates that it is probable that in certain districts in the United States uniform crops of Cuban tobacco having a highly desirable flavor and aroma can be produced by the aid of systematic seed selection.

In the Connecticut Valley this variety is grown under shade for cigar wrappers, the top leaves being used to a limited extent for cigar fillers, and it is grown for cigar fillers in Florida, Texas, Ohio, and Georgia. In Florida and Texas it produces one of the best grades of domestic fillers.

Zimmer Spanish.—Largely used for cigar fillers, and is the most popular and extensively grown domestic filler. It is frequently used for blending with other tobaccos in cigar fillers. It is commonly believed to be a hybrid of the native Seedleaf and the Cuban variety. Adapted to light loam soil, and in the Miami Valley, Ohio, where this variety is most extensively grown, the surface soil is underlaid by a red-brown clay loam. The leaves are medium in size, have good body and elasticity, with small veins, and they resemble the Cuban variety. The leaves are set close together on the stalk, from 14 to 20 leaves to the plant, the plants reaching an average height of about 4 feet. This variety produces an average yield of about 600 pounds to the acre and brings an average price of about 7 cents a pound.

Grown in Ohio and Wisconsin.

Little Dutch.—Used for cigar fillers, making a cigar with an aroma resembling the Yara tobacco grown in eastern Cuba. Adapted to clay loam soils. The seed was introduced in this country from Germany. The leaves are small and narrow and the plants have a short habit of growth, producing a light yield. This tobacco requires careful curing and fermentation.

Grown in Ohio and to a limited extent in Pennsylvania.

PIPE TOBACCOS.

North Carolina Bright Yellow.—Used for manufacturing plug and smoking tobaccos, cigarettes, and for export purposes. This variety is adapted to sandy soils, underlaid by a red or yellow clay subsoil. The deeper the sand the brighter the tobacco produced, and the nearer the surface the subsoil comes the more inclined the tobacco is to darken in color. The leaves are light and spongy, of rather thick texture, set close together on the stem, with an erect habit of growth, but drooping at the ends, the tops often touching the ground. This variety is a modified type of the native Maryland and Virginia tobaccos.

Grown in North Carolina, Maryland, Virginia, and South Carolina.

Maryland Smoking.—Used for manufacturing and export purposes. Adapted to clay loam and sandy soil. The leaves are thick and coarse in texture, but are light and chaffy when cured. They have a semi-erect habit of growth, drooping at the tips, varying in length from 20 to 36 inches and in width from 10 to 26 inches. The plants bear from 10 to 18 leaves and reach an average height of about 4 feet. This variety was discovered in Maryland when the first settlers explored that region. It is mostly exported to France, Germany, and Holland.

Grown in Maryland, Virginia, and Pennsylvania. From the Maryland tobacco many of the important native varieties have been developed by growing in different tobacco-growing sections and by continued selection of seed for a particular type of tobacco.

PLUG TOBACCOS.

White Burley.—Used for plug fillers and wrappers for smoking and for the manufacture of cigarettes. Adapted to well-drained, deep-red clay-loam soil. In Kentucky such soils are fairly rich in lime and produce good crops of corn, wheat, hemp, and grass, but they deteriorate rapidly unless the fertility is maintained by the use of fertilizers and proper methods of cultivation. The leaves are long and broad and have a white appearance in the field. They have a horizontal habit of growth, the tips hanging down and often touching the ground. They vary in length from 28 to 36 inches and in width from 16 to 24 inches. The plants bear from 10 to 18 leaves and reach an

average height of about 4 feet in the field. This variety is a selection from the original Burley, the peculiar white, translucent appearance of the original parent plant having attracted the attention of the growers. Seed saved from this plant produced a large number of plants the following season, and in time a large and important industry was developed from this beginning.

The Red Burley and dark tobaccos of southern and western Kentucky and Tennessee are heavy tobaccos, nearly related to the White Burley, but on account of their peculiar characteristics are largely exported.

Grown in Kentucky, southern Ohio, Tennessee, and to a limited extent in North Carolina and Virginia.

Orinoco and Yellow Mammoth.—Used for plug wrappers and fillers and are stemmed for export trade. Adapted to rich, well-drained soils, doing especially well on alluvial soils underlaid with red clay subsoil. The Orinoco variety has short, broad leaves, while the Yellow Mammoth has large leaves, both varieties having a rapid rate of growth. The Little Orinoco type has a long, narrow, tapering leaf, and is the sweetest variety grown. The Yellow Mammoth is largely exported for Swiss trade, and its culture is mainly confined to Tennessee.

The Orinoco type is grown in Virginia, North Carolina, Tennessee, West Virginia, and Missouri.

Virginia types (Blue Pryor, Sun-Cured, and White Stem).—Adapted to sandy soil, underlaid with red or yellow clay subsoils. These types have very broad, large, fine leaves, of fine, silky texture, with rather tough fibers and usually have bright, fine colors. Some of the best grades are used for cigar wrappers and others for smoking purposes.

Grown in Virginia, North Carolina, Kentucky, Tennessee, Missouri, and Indiana.

DIRECTIONS FOR CULTURE.

SUMATRA TOBACCO.

The location selected for the seed bed should have a slightly southern exposure in order to get the full benefit of the warm rays of the sun in the early spring. The slope should be sufficient to insure perfect drainage at all times. It is desirable that the seed bed be surrounded by board walls and covered with regular tobacco tenting cloth, an illustration of which is shown in Plate II, figure 1. The cover will protect the tender plants from the cold north winds and produce more uniform and favorable conditions, insuring early, rapid growth. The location should be permanent, abundantly fertilized every spring, and kept free from weeds and grass at all times. The soil becomes better adapted to plant-bed purposes each succeeding year if this method is

followed. The most desirable soil seems to be a rich, friable sandy loam. Deep plowing or spading should be avoided in the preparation of the soil, the usual depth being 4 or 5 inches. The ground should be harrowed and stirred with hand rakes until thoroughly pulverized, and all roots, tufts, and clods of earth should be carefully removed.

After this preparation a liberal application of fertilizer rich in nitrogen and potash should be evenly distributed over the bed. A fertilizer containing 10 per cent of ammonia, 8 per cent of available phosphoric acid, and 12 per cent of soluble potash is highly recommended. Chlorin in any form must be avoided. After applying this fertilizer the bed should be thoroughly stirred again and left very smooth, in which condition it is ready for the seed. It is customary to sow the seed at the rate of about 1 tablespoonful to 100 square yards of seed bed. It is impracticable to sow this seed alone and it should be thoroughly mixed with wood ashes, corn meal, land plaster, or commercial fertilizer. In order to obtain a uniform stand of plants it is advisable to sow half of the seed lengthwise of the bed and the remainder crosswise.

The proper time for sowing the seed is from February 1 to March 1. Wherever practicable it is best to prepare the land and apply the fertilizer from one to two weeks before sowing the seed. After sowing, a light roller should be run over the bed, or some other means used to get the soil in a firm, compact condition, in which state it will retain its moisture, thus giving more favorable conditions for the germination of seed and the growth of the young plants. The necessity of properly caring for the seed bed can not be too strongly emphasized, since nothing is of more importance in obtaining a vigorous growth in the field than strong, healthy seedlings. They should be made to grow steadily and vigorously without being checked until ready for transplanting. In order to obtain this condition, strict and constant attention must be given to watering the bed, keeping down all weeds and grass, and preventing the ravages of insect pests. In some cases it is necessary to use an additional application of fertilizer in the way of a top-dressing. The necessity for this is often indicated by the plants turning yellow. The fertilizer should be essentially of the same composition as that previously used, and often gives best results when applied in a liquid form. This method of application makes it necessary to wash the fertilizer thoroughly into the soil by means of an abundant spray and thus avoid injury to the tender plants.

Whenever it is found that the plants are too thick in the bed it is advisable to thin them out by drawing an ordinary rake across the bed, allowing it to sink to a depth of from one-half to three-fourths inch. This can be done without seriously injuring the remaining plants and is, in fact, of positive benefit to them. In all cases some system should be provided for watering the plant beds during spells of dry weather.

Water should be applied in the form of a light spray. During the first two weeks of plant growth it is essential that the surface soil be kept comparatively moist at all times, for at this stage a few hours of hot sun, after the soil has become dry, will be sufficient to kill most of the plants. Where irrigation is used in growing the general crop a system of overhead spray nozzles has been found to give excellent results.

As has been previously mentioned, great care must be taken to remove all weeds and grass that may appear among the young plants. In every case, before undertaking the process of weeding the bed, it is most important to water thoroughly. This will prevent any serious injury being done to the roots of the tobacco plants.

One of the most injurious insects to be guarded against in the cultivation of the seed bed is a flea-beetle. The injury to the plants by this insect may be prevented by the use of a light spray of Paris green. The mixture should be made at the rate of 1 pound of Paris green and an equal quantity of quicklime to 100 gallons of water, which should be kept constantly stirred when in use. The same remedy can be applied in the case of the hornworm, where the seed bed is not inclosed or covered.

A very satisfactory fertilizer consists of 1,000 pounds of cotton seed, 1,000 pounds of cotton-seed meal, 300 pounds of carbonate of potash, 700 pounds of fine-ground bone, and 800 pounds of lime to the acre. The cotton seed should be put on the field after it has been plowed and three weeks or one month before it is finally prepared for transplanting. Wherever it can be obtained cow-pen manure should be used broadcast at the rate of 20 to 25 loads per acre. Cow-pen manure promotes very rapid growth and often becomes the means of securing a good crop of tobacco on land badly infested with nematodes. This kind of plant food enables the plant to throw out new roots faster than the nematodes can destroy the old ones.

When produced for wrapper purposes the Sumatra variety of tobacco is usually grown under shade. The purpose of the shade is to protect the crop from insects and other dangers and by reason of reducing the light to secure a thin leaf. The effect of the shade is also shown in influencing the humidity of the atmosphere and the temperature. The plants under shade show a much more rapid growth than the outside tobacco, and the leaves are finer, very thin and elastic, and with very small veins. Such characteristics as these in wrapper tobacco are desired by manufacturers.

Where no cover crop is grown during the winter the land should be plowed frequently and kept thoroughly stirred. This destroys many of the nematodes, and in that way greatly reduces the damage due to these insects the following year. This constant cultivation also prevents, to some extent, the depredations of the thrips; it prevents the growth of grass and weeds, which serve as host plants for this insect.

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The preparation of the soil for Sumatra tobacco must be thorough and complete. The soil should be thoroughly pulverized by successive plowing and harrowing, and reduced to a fine condition before transplanting. Deep plowing and subsoiling causes a retention of moisture in the soil if the season is too dry, and at the same time affords the best opportunity for proper drainage if there is an excess of rainfall during the growing season. The disk plow and disk harrow have been used very successfully in the preparation of tobacco soils, particularly where the content of clay is comparatively small.

When transplanting the young plants from the seed bed to the field, it is desirable to make a selection of the best and most vigorous plants in the seed bed. At this early stage of growth the most vigorous plants, having the largest and best-shaped leaves, can be very easily distinguished by the grower and selected for the field.

The ordinary distance for Sumatra under cloth is 3 feet 3 inches apart for rows and 12 inches apart in the row. Under slat shades the distance between the plants in the row is usually increased to about 14 inches.

Before removing the young plants from the seed bed, the bed should be thoroughly watered and the plants taken out with all possible care. In setting the plants in the field care should be taken to avoid bending and doubling the roots, and the necessary application of water should not be overlooked. It is often found beneficial, just before transplanting, to water the soil where the plant is to be set, and to water again shortly after transplanting.

The cultivation of the crop should include the removal of all weeds from the field, particularly during the early stages of growth, and a thorough cultivation of the soil at frequent intervals in order to keep a loose mulch on the surface of the soil. It is usually the custom to hoe the young plants twice and to use some form of cultivator at least once a week during the remainder of the season until the plants have become too large for cultivation. In many instances it has been found desirable and practicable to cultivate the tobacco until shortly before the top leaves are taken off. In dry seasons this serves to retain the soil moisture by preventing excess evaporation due to soil capillarity.

When the plants begin to bud, all except the individual plants saved for seed purposes should be topped. No very definite rule can be given for this process, but it is the usual custom to break off the top of the plant just below the first seed sucker. The height of topping must be largely governed by the local soil and climatic conditions.

It is necessary to remove the suckers before they reach sufficient size to seriously injure or dwarf the plant or interfere in the development of the leaves. In most cases it will be found necessary to remove the suckers two or three times, and more frequently if the season is one which promotes rapid growth. If seed is to be saved on any of

the plants, the flower cluster should be covered with a light and strong paper bag before any of the flowers blossom out, in order to prevent cross-fertilization. The bags should be kept in good condition and not allowed to injure the top of the plant in any way. They should remain over the flowers until a sufficient number has been fertilized to produce a good supply of seed.

The time for harvesting will depend to a considerable extent upon the season, but the ripeness of the leaves can be distinguished by the development of irregular, light yellowish colored patches over the surface and a thickening and crumpling of the body of the leaves. The leaves should be harvested before they become overripe, and it is the usual practice to pick them at three or four different periods, the lower leaves maturing first, the middle leaves next, and the top leaves last, generally allowing from six to eight days between each picking. After picking, the leaves are carried to the curing shed in baskets made for this purpose and are strung on 4-foot laths specially arranged for them at the rate of 30 to 40 leaves to the lath. The leaves are arranged back to back and face to face, and are regularly strung on the cord attached to the lath. The laths are then hung in the curing shed, where the leaves are allowed to thoroughly cure out.

When the tobacco is primed from the stalk it should not take more than three weeks to cure; when it is hung on the stalks from four to six weeks are necessary. The manipulation of the curing barn is governed entirely by the condition of the weather and the nature of the tobacco, so no fixed rules can be given. However, in a general way it can be said that the barn should be opened during the day and kept closed at night. If there are frequent showers and but little sunshine, the barn should be kept closed and small fires started, distributed throughout the building. These fires should be continued as long as it is necessary to dry out the entire barn of tobacco. Where charcoal is not available, wood which has as little odor and as little smoke as possible should be used. It is very important to dry out the barn without giving the tobacco any foreign odors. To obtain the best results the tobacco should become moist and be fairly dried out once in every twenty-four hours.

When the midribs are thoroughly cured the leaves are ready to be taken to the packing house. To get the tobacco in condition to handle, all the ventilators should be left open for one night, opening them about 6 o'clock in the evening. Unless the night is a dry one, the tobacco will soften before morning and be in condition or "good order;" that is, it will have taken up sufficient moisture to make it soft and pliable. The barn should then be tightly closed, in order to retain the moisture, and the leaves taken from the laths and tied into hands of convenient size. The bottom, middle, and top leaves should be kept separate in the barn. After the tobacco has been

taken down and packed it should be taken at once to the warehouse for fermentation.

The fermentation of the tobacco is to be done in bulk, and this sweating process must be watched with unusual care in order to prevent disaster to the crop. It is necessary to turn the bulk several times during the process of fermentation in order to keep the temperature at the desired point. The object of turning the bulk is to reverse its construction, thereby bringing the top, bottom, and outside layers into the middle of the new bulk. This plan will permit a uniform fermentation of all the tobacco in the bulk. A convenient and practical size of bulk contains from 2,000 to 3,000 pounds. The temperature of the center of the bulk should in no case be allowed to rise above 120° F., and after the temperature falls from 8 to 10 degrees the bulk should be turned. The desirable maximum temperature is 115° F. It takes usually from six to eight weeks to complete the process of fermentation. After fermentation the tobacco must be sized, sorted according to the different market grades, tied up in hands, and packed.

CONNECTICUT HAVANA TOBACCO.

There is a very limited amount of plant food in tobacco seed on account of the small size of the individual seed, so that the reserve material for the nourishment of the young plants is soon exhausted; consequently the tobacco seedlings are forced to prepare their own food much sooner than is the case with most other crops. For this reason it is absolutely necessary for tobacco growers to get the soil and plant food in the seed beds in the best possible condition for use by the young plants in order to aid the slow-growing young plants during the critical period of the first stages of growth. The seed beds should be located so that they will get all the benefit possible from the warm rays of the sun during the early spring days, as well as protection from the cold north and northwest winds prevalent at that time of the year. A southern slope where good drainage can be secured is preferable, and a good, rich, and friable soil is desirable for the tobacco seed beds.

As a rule 200 square feet of seed-bed space should be provided to furnish sufficient seedlings for an acre of tobacco, although if the tobacco is to be transferred at different periods a less area will be found to be sufficient. The seed beds are generally 8 feet wide and as long as is necessary to furnish sufficient seedlings for the field. They are usually laid out from east to west.

The framework of the seed bed is usually made of 2 by 12 inch boards, set in the ground from 3 to 4 inches, one side being sunk 2 inches lower than the other in order that the sash may lie over the

top of it in a slanting position, so that the plants will receive all of the sunlight possible.

The best method of covering the bed is by means of glass in sash about 3 feet wide by 8 feet long. These sash are laid over the top of the framework and of course can be removed at any time when it is necessary. In some cases heavy cheese cloth or tobacco cloth is substituted for the glass covering, but the temperature of the beds can not be regulated so well as with the glass cover, and the cloth should not be used where very early plants are desired. It is claimed by old tobacco growers, however, that the plants raised under cloth are more hardy than those raised under glass, and it is a frequent practice to grow the early plants under glass and the later seedlings under cloth. In Plate II, figure 2, are shown the cloth tent seed bed, the cloth-covered cold-frame seed bed, and the glass-covered seed bed, which are most practicable and successful for the raising of seedlings.

When it is necessary to water the seed bed the sash are removed temporarily and the water is applied in the form of a fine spray. As soon as the watering is completed the sash are replaced in their original positions. If it becomes necessary to air or cool the beds one or more sash can be raised until the desired object is accomplished.

The soil for the seed bed should be a light sandy loam, as free from weed seed, fungous diseases, and insect pests as possible. It has been found that by sterilizing the soil used in the seed bed the expense of weeding the beds can be done away with. The sterilization of the seed-bed soil results in the production of better plants than are grown in soil which has not been sterilized and also destroys the fungous spores which frequently interfere with the successful raising of young plants. In Plate III, figure 2, is shown a simple and practicable method of sterilizing the soil with steam. The upper 6 inches of the soil in the seed beds is removed and placed in an ordinary wagon box, in the bottom of which three perforated pipes are laid and attached to a steam boiler. The sterilization process requires about 40 minutes for each wagon box of soil, the time being determined by placing a potato in the soil and supplying steam until the potato is baked. A large quantity of surface soil in the seed beds can be sterilized in this manner in a comparatively short time with little expense.

A successful method of heating seed beds is by the use of fresh horse manure. In this case the beds should be dug out 2 feet deep about a week before the time for sowing the seed. The fresh manure should be packed in this space to a depth of 1½ feet and covered with 6 inches of the sterilized soil. Another successful method of heating the seed bed is by the use of hot-water or steam pipes, laid around the sides of the bed or under the surface of the soil. General experience has proved, however, that the manure beds are equal in value, if not superior, to the artificially heated ones, mainly from the fact that the

heat is distributed evenly through the soil in the seed bed, while in the case of hot-water or steam pipes the surface of the bed or the air space is likely to be hot while the soil may remain cold and in poor condition for the growth of the young plants.

The soil for the seed beds should be fertilized with a highly nitrogenous fertilizer, the one most commonly used being cotton-seed meal in combination with a complete fertilizer containing phosphoric acid and soluble potash. This fertilizer should be thoroughly worked into the soil.

In preparing the soil for the sowing of the seed, it should be most carefully handled, so that at the time of sowing it is in a fine, loose, and friable condition, with an even surface. As the tobacco seed is very small, it is necessary to have the soil in the finest possible tilth in order to present a uniform condition for the seed. During the growth of the young plants it is well to sprinkle over the beds a light dressing of nitrate of soda, dissolved in water, after which it should be washed into the soil with a light and fine spray of water. It is sometimes found desirable to add a light application of phosphorus, in the form of ground bone and carbonate of potash, if the soil is found to be deficient in these elements of plant food. It is the usual practice in the North to sprout half of the quantity of seed used for sowing in moist but not too wet apple-tree punk or rotted cocoanut fiber about one week before the time for sowing the bed. For this purpose the seed is thoroughly mixed with the punk and placed in a glass jar, which should be kept in a warm room. The seed will sprout quickly in this medium, and it is probable that earlier plants can be secured from such sprouted seed than from sowing the dry seed alone. The sprouted seed should be sown about the time the sprouts are one-eighth to one-fourth inch in length. Many growers sow the sprouted seed as soon as the seed coats burst and the sprouts appear. If the sprouts become too large they will be injured during the process of sowing. An equal quantity of dry seed should be mixed with the sprouted seed when the beds are ready for sowing.

It has been found by comparative tests made by the Bureau of Plant Industry that in most cases the dry seed produces plants about as early as the sprouted seed, and the plants from the dry seed are more uniform in size and apparently more hardy than those raised from the sprouted and dry seed combined. In order to get an even distribution of seed over the seed bed in sowing, it is a good plan to mix the dry seed and the sprouted seed with several times its bulk of land plaster or gypsum, or, if this is not obtainable, corn meal or ashes, so the seed can be sown more evenly over the bed. One to two tablespoonfuls of seed should be used for every 100 square yards of seed-bed surface.

After sowing the seed it is desirable to pack the surface of the bed carefully with a roller or heavy plank, in order to press the soil closely about the seed. Another good plan is to cover the seed by lightly raking the surface with an ordinary garden rake, and this method is preferred by many experienced growers. It has been found in the experiments of the Bureau of Plant Industry that the light seed is undesirable and in every case should be separated from the heavy seed and discarded. In order to make a thorough and complete separation, it is necessary to use some form of a wind-blast machine which will blow out the light seed without throwing out the heavy seed at the same time. In Plate IV, figure 1, is shown a satisfactory seed separator, by the use of which the light seed can be separated from the heavy seed and discarded, and the heavy seed used for sowing the seed beds. The heavy seed produces the most vigorous and uniform young plants in the seed beds, as shown in Plate IV, figure 2, and these plants are most desirable for use in the case of all varieties of tobacco.

The Havana seed variety of tobacco is usually sown in the seed bed from the middle of March to the middle of April, and the plants are ready for setting out from these beds from May 10 to June 10.

One of the most important points in the raising of a successful crop of tobacco is the care of the seed bed in the production of the seedlings. It is necessary to water the seed bed frequently, usually once or twice every day during the early stages of growth. If the beds are artificially heated, warm water should be used for this watering process, as cold water cools the beds and checks the growth of the young plants. The surface of the seed bed should not be allowed to become dry, as a few hours of dry surface will kill all of the young plants. The water should be supplied in the form of a light spray, in order not to disturb the seed or the young plants in the bed or to pack the soil so that in drying it will cake and injure the plants.

The temperature of the hotbeds should be carefully regulated, and in no case allowed to rise above 100° F. during the day or fall below 70° F. during the night. If it is possible to maintain an even temperature the plants will make the most rapid growth, but it is a question whether they will be as hardy as when subjected to the fluctuating temperatures corresponding to the natural changes between night and day. The beds can be cooled when necessary by raising the sash if the temperature rises, or the temperature can be raised at night by using lanterns set 5 or 6 feet apart in the seed bed and by covering the sash with heavy cloth, such as ordinary blankets, in order to retain the heat. After the young plants reach the proper size for setting out, usually from 5 to 6 weeks after sowing in the seed bed, the sash can be taken off most of the time during the day and the beds watered only when the plants begin to wilt. If the plants come up too thick

in any portion of the seed bed, they should be thinned out by using an ordinary garden rake and pulling it through the thickly set plants. Sufficient plants will be removed in this way, and those which remain will not be injured by the thinning process, but will be benefited by the stirring of the surface soil. It is also necessary to keep out all weeds, carefully pulling them as soon as they appear among the tobacco plants. Before pulling the weeds, the beds should be thoroughly watered. If flea-beetles or other biting insects attack the young plants in the seed bed, the plants should be sprayed with a Paris green mixture at the rate of 1 pound of Paris green and an equal quantity of quicklime to 100 gallons of water. If fungous diseases begin to grow in any portion of the seed bed, it should be thoroughly aired by raising the sash during the day, and if this method does not check the growth of the fungus the beds should be sprayed with a solution of formalin—1 part of formalin to 2,000 parts of water. An application of lime dusted over the beds will also assist in preventing the spread of fungous diseases.

The preparation of the field for the plants should be begun in the autumn, if possible, by plowing the land 2 or 3 inches deep and sowing a cover crop, such as vetch or some other legume. These leguminous cover crops not only prevent washing and loss of fertility during the heavy rains of the fall and winter, but increase the fertility of the soil through the addition of the nitrogen in the tubercles of these plants and by reason of their extensive root development, which tends to break up and put the soil in the best possible tilth for the young plants. In the spring the land should be replowed, care being used to see that the cover crop is thoroughly plowed under, with an application of well-rotted stable manure at the rate of 12 to 15 tons to the acre.

In addition to the use of stable manure, it has been found that the following or a similar fertilizer should be used in order to secure the best results: One ton of cotton-seed meal, 200 pounds of carbonate of potash, 500 pounds of starter, and 1 barrel of lime to the acre. This commercial fertilizer should be sowed on the land after plowing and worked into the soil with a disk or by some other means of thorough stirring before the young plants are transplanted into the field. When the young plants are pulled from the seed beds the bed should be thoroughly wet down before pulling, in order that as little injury to the plants as possible may be inflicted during the process of pulling. The plants are usually set out with a tobacco setter, such as is shown in Plate III, figure 1. If possible, it is desirable to transplant after a shower or during a moist spell of weather, as the hot sun on the young plants in the fields is likely to cause considerable injury. Immediately after transplanting, the young plants should be dusted with a bran mash and Paris green mixture made by mixing thoroughly 1 pound of Paris green with 100 pounds of bran. This mixture can be applied to

the plants by dusting through a perforated tin box, or in some cases a small fertilizer sower is used for this purpose.

In transplanting the young plants from the seed bed it is desirable to make a selection of the best and most vigorous plants. At this early stage of growth the differences in shape of leaf can be detected by an inspection of the seedlings. For the Havana Seed variety the plants should be set in rows 3 feet 3 inches apart, and the plants should be set 18 inches apart in the row. If the plants are set by hand great care should be used not to bend or otherwise injure the roots of the young plants, as such injury may result in a diseased condition of the plant, making it almost worthless for wrapper purposes.

In cultivating the field a shallow or surface cultivator should be used and the soil kept stirred frequently in order to conserve soil moisture, as well as to remove all weeds. It is usually found necessary to hoe the field once or twice during the early stages of growth in order to remove all of the weeds and to loosen the soil around the young plants and keep it in the best possible condition for their most favorable growth.

When the plants begin to bud all except the individual plants saved for seed purposes should be topped. No very definite rule can be given for this process, but it is the custom to break the tops off the plants just below the first seed sucker. As a rule the height of topping must be governed by local conditions, such as the soil fertility and the season. In most cases two or three of the top leaves are removed in topping. It is necessary to remove the suckers before they reach sufficient size to seriously injure or dwarf the plant or interfere with the development of the leaves. It will usually be found necessary to remove the suckers two or three times during the season in order to keep the plants free from these injurious branches.

It has been found in the tobacco-breeding investigations that by selecting seed from plants having few suckers, sucker-resistant types of tobacco can be secured, and it is recommended that in the case of all of the wrapper varieties of tobacco, particularly the Havana Seed tobacco, such a plan of seed selection be followed. In saving seed from carefully selected plants the flower clusters should be covered with a light and strong paper bag before any of the blossoms open, in order to prevent accidental cross-fertilization. These bags should be of light but strong paper, and should be kept in good condition and moved up the stalks occasionally so as not to allow the bags to injure the tops of the plants in any way. These bags should remain over the seed head until all of the flowers that are to be used for seed-saving purposes have been fertilized, after which the bags can be removed and the seed allowed to mature in the open.

The time for harvesting this variety of tobacco varies with the season, but the ripeness of the leaves can be distinguished by the devel-

opment of irregular, light yellowish colored patches over the surface and a thickening of the body of the leaves. By crumpling the leaf, if the surface breaks in straight lines, or "cracks," as the old growers are accustomed to call it, the leaf is said to be in proper shape for cutting.

The plants are usually cut with a regular tobacco hatchet or knife and are strung on laths, as shown in Plate V, figure 1. Five or six plants are usually strung on each lath, after which they are hauled to the sheds in wagons specially prepared for this purpose. A wagon with special rack arranged for transporting the plants from the field to the curing shed is shown in Plate V, figure 2. These laths are usually 4 feet in length, and are so hung in the curing shed that a space is left between each plant in order to get a circulation of air. A common type of curing shed filled with tobacco is shown in Plate VI, figure 2.

The curing process requires as a rule from 4 to 6 weeks. The manipulation of the barn or curing shed during this period is entirely governed by the conditions of weather and the nature of the tobacco, so that no fixed rules can be given. However, in a general way it can be said that if the barn is filled with green tobacco and the weather is hot and dry the ventilators should be open most of the time for about 3 days, by which time the tobacco should begin to yellow. The ventilators should only be closed to prevent too rapid curing during this period. The barn should then be opened at night and kept closed during the day. This is done to prevent too rapid curing, which destroys the life of the leaf and produces uneven colors in the tobacco. If there are frequent showers and but little sunshine the barn should be kept closed, and if there are indications of pole-burn or pole-sweat, small fires, at least two in every bent in the shed, should be started. In order to dry out the tobacco in as short a time as possible, these fires should be distributed throughout the shed and the tobacco above the fires protected by hoods. The best material for making these fires is probably charcoal or coke, but if these two materials can not be used soft pine wood may be found to be satisfactory. In no case should hard wood be used, as certain odors are given off which it is impossible to get out of the tobacco, and these injure the quality and the sale of the crop. To get the best results, the tobacco during the curing process should be kept fairly moist and fairly dried out once in every 24 hours.

After the curing process has been finished the tobacco is usually sorted according to grade and color as laid down by the tobacco trade. The tobacco is then arranged in hands and packed in cases, where it is allowed to go through natural fermentation, or it is placed in a room which can be heated and is there put through a forced sweat. If the natural fermentation takes place it usually does not begin until the warm weather of the succeeding summer. Great care must be used

in the fermenting processes that the tobacco is not damaged by the spread of fungous diseases, mold, or other causes of injury to tobacco in cases. The cases are usually arranged to hold about 350 pounds of tobacco.

CONNECTICUT BROADLEAF TOBACCO.

The methods of sowing the seed, preparation of the seed beds, and treatment of the beds are practically the same for the Connecticut Broadleaf as in the case of the Connecticut Havana variety. Many of the growers in the Connecticut Valley prefer the tent cover for the seed beds for this variety, two forms of which are shown in Plate II, figure 2. The advantage in the cheese-cloth or light-muslin cover for the seed bed lies in the fact that plants grown under such conditions are as a rule more hardy than plants raised under glass. As the Broadleaf plants make a very rapid growth in the seed bed and field, hotbeds for the production of early seedlings are not as essential as with other slower growing varieties. To sow the seed mix one tablespoonful for every hundred square yards of seed bed with 2 quarts of ashes or meal in order to get an even sowing, and lightly rake the surface of the bed so as to barely cover the seed. If the seed is covered too deep, it will not germinate.

The seed bed should be kept moist, but not too wet, as too much water not only injures the seed, but favors the development of fungous diseases. In about two weeks after sowing, the young plants will appear, but at this time they make a very slow growth, as the plant food in the seed has been exhausted and the plants must meet new conditions. At this stage, if the surface of the bed dries out, the young plants will be killed, so that it is absolutely necessary to use the greatest possible care in watering the beds. After the young plants have developed root systems and become established for independent growth they make a very rapid growth, and it is usually desirable to apply liquid manure. If the seedlings begin to turn yellow, it is a sign that more plant food is necessary, and this can be applied in liquid form. The young plants should be set out when the leaves are about five inches long. Large plants are not desirable, as they grow spindling, while very small plants are likely to die after transplanting if any unfavorable conditions develop. In transplanting, the beds should be thoroughly watered before pulling the plants in order to avoid disturbing or injuring the roots. After pulling the plants they should be placed in a basket, roots downward, and set in a shaded, cool place until set out in the field.

The preparation of the land for planting should be thorough, and the soil should be in as good tilth as possible. Cover crops, such as vetch, are desirable for plowing under. A disk cultivator is a good implement to fine the surface soil, after which the land should be fitted

with drag and harrow, in order to get the surface as level and fine as possible. The land is usually fertilized with well-rotted barnyard manure, at the rate of from 8 to 12 tons per acre, plowing it under in the spring. Frequently tobacco stems, at the rate of from 500 to 600 pounds per acre, are used as a fertilizer in the Broadleaf sections. Most crops of Broadleaf tobacco are grown on these fertilizers alone, but in recent years the growers have begun to apply about 1 ton of cotton-seed meal, 200 pounds of carbonate of potash, and from 1 to 2 barrels of lime per acre in addition to the usual tobacco starter.

The seedlings of the Broadleaf variety are usually set in rows 4 feet apart and the plants from 22 to 24 inches apart in the rows. In all cases water should be used in transplanting, even if the ground be moist. If the plants are set by hand, one person distributes the plants at the proper distance along the rows, followed by a man or boy who, with a round stick, makes a hole for the plants. A third person sets the plants in the holes and presses the soil firmly about the roots, leaving the surface of the soil as loose as possible. As the plants are set in the holes, a cupful of water should be poured into the holes, and some growers prefer to add water to the plants directly after they are set, although this practice leaves the soil about the plants in such condition as to bake, especially during a hot, dry day.

The object of the cultivation of the field is to keep the soil in as good condition as possible and to prevent the growth of weeds and the loss of soil moisture. In most cases a loose mulch should be maintained by frequent, shallow, level cultivation. As the plants grow, the soil should be stirred with a hoe around the plants. One of the best cultivators is called the Prout hoe, which is adjustable to the width of the rows, the small shovels leaving the surface with a fine even texture.

The topping process is necessary in order to direct the strength of the plant into the development of the leaves. After topping, the surface of the leaves very rapidly increases, the leaves thicken, and the ripening processes are hastened. The Broadleaf plants are usually topped below the first large sucker. If it is found desirable to hasten the ripening process, the plants are topped low, while if necessary to prevent the development of too thick leaves the plants should be topped high. Usually the topping process is delayed until most of the flower buds appear, so that the topping can all be done in one operation, but many growers prefer to remove the buds as soon as they appear, going over the field later and topping to the desired height. As soon as the suckers appear they should be broken off, and in order to do this effectively it is necessary to go over the field once a week after the plants have been topped.

The time to harvest the crop can only be determined by experience with the strain which is grown. As a rule, a ripe leaf has a rough feeling to the touch, and there is a change in the color of the leaf from

a dark to a lighter green; also, by folding the leaf between the fingers a ripe leaf will break easily. In the Broadleaf variety the plants are usually cut, and as all the leaves on a plant are not ripe at one time, it is necessary to harvest the crop when the majority of the leaves are in the proper condition or about the time that the middle leaves are ripe. Overripe leaves lose their elasticity and strength, and are not suitable for cigar wrappers. The plants are speared on 4-foot laths, using a detachable iron spearhead fitted in the end of the lath, as shown in Plate V, figure 1, placing from 4 to 6 plants on each lath.

The Broadleaf tobacco is air cured, the process taking about six weeks. After harvesting, the plants are immediately hung in the barn, and the temperature and humidity of these sheds must be closely watched and controlled by means of the ventilators. If the leaf cures too rapidly the ventilators should be opened on moist days and nights and closed on dry days. If the curing process proceeds too slowly or the tobacco is liable to injury from pole-burn or other fungous diseases, the ventilators should be opened on dry days and closed on moist days and at night. In long-continued damp spells of weather, when the tobacco can not be dried out by opening the ventilators during the day, small fires of soft pine or charcoal should be used to drive off the excess of moisture and raise the temperature in the barns.

The Broadleaf tobacco is usually fermented in cases holding about three hundred pounds, the hands of tobacco being laid in these cases with the butts of the hands on the outside and the tips in the center. The tobacco is then pressed down under moderate pressure, the tops of the boxes screwed on, and the cases kept in a room having an even temperature.

CUBAN TOBACCO.

Cuban tobacco is grown without shade when used as a filler for domestic cigars. The percentage of wrappers in this outdoor crop is not large, but when the leaves are primed the percentage of wrappers is considerably increased. The preparation and care of the seed beds and methods of cultivation are about the same as in the case of the Sumatra variety. The rows in the field are arranged about 3 feet 4 inches apart and the plants set about 14 inches apart in the row. A greater distance results in thick, heavy leaves. If the plants are set too close the leaves are too thin and lacking in body for filler purposes.

No definite rule can be laid down as to the proper number of leaves to be left on the stalk when the plants are topped. This number varies with the height of the plant and the climatic conditions during the season. From 14 to 16 leaves, however, are considered desirable during the ordinary season. The suckers begin to appear very soon after topping and should be removed every 8 or 10 days or once a week when rains are frequent.

Worms are usually very troublesome on this variety of tobacco and must be picked off and destroyed as soon as they appear, or they can be poisoned with a very light spray of Paris green mixture. The "powder gun" has come into general use and is rapidly replacing the spray pump for poisoning the hornworm and budworm. The growers who still employ the spray pump use 1 pound of Paris green and an equal quantity of quicklime to 100 gallons of water, this being sufficiently strong to kill the hornworms without injuring the leaves. If a stronger solution is used there is danger of burning the leaves, so that patches of green will appear after curing. A mixture of 1 pound of Paris green to 30 pounds of lime or land plaster is recommended for use in the powder gun.

The manner of harvesting the southern Cuban tobacco is essentially the same as that practiced with the Connecticut Havana Seed tobacco. The number of plants to the lath, however, may be increased to 8 or 10, where the growth is comparatively small.

Some growers prefer to prime the Cuban tobacco. This process is more expensive, but a thinner leaf is obtained, which makes it possible to use a certain percentage of leaves for wrapper purposes. There are no advantages in this system over the present method of cutting the plants so far as the production of a filler leaf is concerned.

Where the soil has been abundantly fertilized and the season is favorable, a profitable second crop of filler can be grown, which is commonly called a "sucker crop." A week after cutting, all the suckers should be broken off the old stump with the exception of one, which is to be allowed to remain and mature. It should be handled in exactly the same way as the original crop. The sucker crop ordinarily produces about one-half the yield of the main crop. Insects are always very much worse late in the season and become very troublesome in the sucker crop.

ZIMMER SPANISH AND LITTLE DUTCH TOBACCOS.

The preparation and care of the seed bed for Zimmer Spanish and Little Dutch varieties should be the same as given for Connecticut Havana tobacco. The preparation of the soil and the methods of transplanting and cultivating are the same as those given for Connecticut Havana. The plants should be set in rows 3 feet apart and the seedlings set from 15 to 20 inches apart in the rows. The plants should be topped so as to leave about 16 leaves for each plant. The average yield of the Zimmer Spanish variety is about 600 pounds to the acre, while the yield of the Little Dutch variety is considerably less. The methods of harvesting, curing, and fermenting are essentially the same as those for the Connecticut Havana variety.

MARYLAND SMOKING TOBACCO.

The seed bed should be located on a dark, friable, loamy soil with a southern exposure. The plants may be easily watered if the seed bed be located near a brook. The old method of burning the seed bed has been largely abandoned, but, if used, care should be taken to burn only small timber and brush. A large quantity of ashes is detrimental to the growth of the young plants. All trees within 30 or 35 feet should be cut down and piled on the north and west sides of the seed bed for a partial protection against the cold winds.

The proper time for preparing and sowing the seed bed is from February 1 to March 30. The bed should be spaded to a depth of 4 or 5 inches, and all roots and tufts carefully removed. The soil must be thoroughly pulverized with garden hoes, hand rakes, or other suitable implements. Before the last stirring an application of a highly nitrogenous fertilizer should be evenly distributed over the bed and thoroughly incorporated into the soil. A mixture of 50 pounds of nitrate of soda, 40 pounds of fine-ground bone, and 10 pounds of carbonate of potash, applied at the rate of 30 pounds per square rod, is highly recommended.

Sow the seed at the rate of two tablespoonfuls to the square rod. It can best be uniformly distributed over the bed by mixing with wood ashes or land plaster, dividing it into two equal parts, and sowing half of it over the bed crosswise and the other half lengthwise. The sides of the bed should be from 8 to 10 inches high, and wires 3 feet apart should be stretched across it. The beds can be covered with light cheese cloth or tobacco-bed cloth, after the seed has been sowed. The covering serves as a protection against the ravages of the flea-beetles and other insects, provided there are no open spaces around the bed. All weeds and grass should be removed. It is seldom necessary to water the plant beds, except in the case of unusually dry weather. Water at this time is very essential. It should be applied as in the northern seed beds, but less frequently, it being seldom necessary to water the beds more than twice a week.

In most cases it is advisable to replenish the plant food with a top-dressing or fertilizer of the same composition as that of the first application. This should be applied in liquid form, wherever it is possible to wash it in thoroughly; otherwise it is most important to top-dress the beds only during hot, dry days. The top-dressing should be used when the plants are from 2 to 3 inches high. Where cloth is not used for a covering, the beds must be closely guarded against the attacks of the flea-beetle. When this insect first makes its appearance the plants should be treated with Paris green at the rate of 1 pound to 30 pounds of land plaster. The cloth covering should be removed from the beds

at least a week before transplanting to prevent the injurious effect of the radical change from the seed bed to the open field.

Maryland tobacco is transplanted from May 15 to June 15. Care must be used to wet the seed bed down thoroughly before drawing the plants, thus protecting the roots from injury. The mottled or mosaic tobacco, so common in Maryland tobacco fields, is frequently due to the practice of drawing the plants when the soil is not thoroughly moistened. This variety should be set in the field in rows 3½ feet apart and the plants 20 to 35 inches apart in the row.

Tobacco should be preceded by a leguminous crop of some kind, hairy vetch being highly recommended for this purpose. In addition to the nitrogen from the leguminous crop a fertilizer rich in potash and containing a moderate amount of phosphoric acid should be added before transplanting. The best stand is obtained in the field where the land has been plowed deeply and harrowed several times, thus leaving a thoroughly pulverized soil for the reception of the plants. The methods of cultivation, topping, suckering, and harvesting are essentially the same as in the case of the Connecticut Havana variety.

NORTH CAROLINA, TENNESSEE, AND VIRGINIA TOBACCOS.

The methods of sowing the seed and of preparing and caring for the seed bed are the same in the case of North Carolina, Tennessee, and Virginia tobaccos as those used by the Maryland growers. The seed, however, may be sown at least a month earlier than in Maryland.

Two systems of harvesting are in general use, both of which have certain advantages. One of these systems is to prime the leaves as fast as they ripen and string them on laths, allowing 30 to 32 leaves to a lath. The other and more common system is to cut the entire stalk and cure the leaves on it, as is done with the Connecticut Havana variety.

The North Carolina, Tennessee, and Virginia tobaccos are usually flue cured or fire cured, for which purpose a special type of barn is used. The essential points of this barn are that it be practically airtight and provided with one or two furnaces having flues leading up through the center of the barn, giving a large heating surface. There should be at least two small ventilators on or near the top of the barn.

As soon as the barn is filled with tobacco, fires should be started and the temperature raised to 90° F., where it should remain from 24 to 30 hours, during which time the tobacco becomes a uniformly bright yellow. The next step in curing is to raise the temperature from 90° to 120° F. for 15 to 20 hours. This process is commonly known as "fixing the color." Then the temperature may be increased gradually to 125° F., at which point it should be maintained for about 48 hours. By this time the leaves should be almost, if not entirely, yel-

low, but the stalk will still be green. In order to cure out the stalk, the temperature can be raised to 175° F., at the rate of 5 degrees an hour, where it should remain until the stalks are thoroughly dried. Great care must be taken during the entire process of curing not to allow the temperature to fall, for a lowering of the temperature during the process of curing invariably produces discolorations in some parts of the leaf.

WHITE BURLEY TOBACCO.

The seed bed should have a slightly southern exposure in order to get the benefit of the warm rays of the sun in the early spring, and the beds should be protected from cold winds. The best soil for the White Burley tobacco is a rich, friable, virgin loam or sandy soil. The best plan is to burn and prepare the seed bed on old sod lands. Many farmers select a spot in a vegetable garden and cover it with virgin mold taken from the woods, and sow it, after thoroughly burning the land until it has a reddish or brick-like appearance, when it should be spaded up and thoroughly chopped over with hoes until it is fine and even. The ashes should not be raked off, but should be thoroughly mixed in with the soil. As soon as the ground can be worked in the spring, it should be lightly spaded and thoroughly loosened to a depth of 2 or 3 inches with harrows or hand rakes. When in good condition, it should be marked off in beds about 4 or 5 feet wide and seeded. It is the usual custom with this variety to use a heaping tablespoonful of seed for every 100 square yards of seed bed. After sowing, the best plan is to run a heavy hand roller over the bed or press it with a board or with the feet. As a rule, the bed is tramped over with the feet until the surface is packed. The seed bed is usually protected by a canvas covering to prevent the ravages of flea-beetles and to keep the bed moist and warm.

The preparation of the land is generally begun in the month of March, the usual plan being to turn under the soil with a 2-horse plow to a depth of about 8 inches. About the middle of April a revolving disk or harrow is run over the land in order to cut the sod to pieces, after which the field is smoothed over with a slab drag. It is very rare for fertilizers or manure of any kind to be used in the White Burley districts. Tobacco stalks and trash from the barnyard are preferred to any other fertilizer for this tobacco. Owing to the fact that the crop is grown for two years and the field is then put in rotation with other crops, the fertility of the soil is maintained.

The tobacco plants are usually set after a shower, or when there is no rain they are set out in the afternoon. The land is cultivated with a bull-tongue cultivator during the first week or so, and then cultivated every week with a double-shovel cultivator as long as it is possible to do so without injury to the plants. As soon as the cultivation is

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finished the plants are topped, leaving from 16 to 20 leaves on each plant. From four to five weeks after topping, the tobacco is usually fully ripe and the plants are cut with a tobacco cutter or butcher knife. The stalks are split down the middle and strung on sticks 4½ feet in length, after which they are taken to the tobacco barn and hung 12 inches apart on the tier poles. When fully cured, the tobacco is sorted, usually into six grades, and the different grades are tied into bundles of from 10 to 20 leaves and packed for the market.

INSECT ENEMIES.

The general subjects of the insect enemies of tobacco and the use of insecticides are considered in Farmers' Bulletin No. 120, entitled "The Principal Insects Affecting the Tobacco Plant," which may be had without cost upon application to the Secretary of Agriculture. In case the seed beds are inclosed or covered, the tobacco is largely exempt from injury by such pests as flea-beetles and hornworms. The tobacco stalk weevil and tobacco thrips are comparatively new as pests. Two accounts of the former have been published and a detailed account of the latter is about to be issued by the Bureau of Entomology, to which office tobacco growers are referred for specific information in regard to methods of controlling insect pests. In the case of arsenicals it is always desirable to use at least an equal quantity of quicklime to prevent injury by free arsenic.

DIRECTIONS FOR SAVING SEED.

In all cases where new seed is taken into a locality it should be thoroughly tested before growing on a large scale. This is especially true of all seed imported from Cuba, Sumatra, Turkey, or other foreign countries. The past few years have witnessed a striking illustration of the effect of using seed direct from tropical regions, such as Cuba and Sumatra, when grown in the northern tobacco districts. The plants grown from this freshly imported seed broke up into many different types, some of which may prove valuable, but most of the types are irregular and undesirable. Therefore it has been a common experience for growers to suffer great losses by reason of the presence of these undesirable types during every season in which the seed was used. This breaking up of type is due to the effect of the change of soil and climatic conditions, resulting in striking variation in the plants grown from the imported seed. The variation is particularly marked where southern seed is taken to northern tobacco districts.

Our experiments have shown that if the seeds from typical and desirable plants in these crops are saved under bag, and thus protected from cross-fertilization, the plants produced from such seed will be uniformly like the parent plants. The uniformity of plants from seed

saved under bag is illustrated in Plate IX, figure 1. The two rows shown in this illustration are from the seed of two plants of different types and all of the progeny are like the parents. The second season it is a good plan to increase the area of plants grown from seed saved under bag, and from the most desirable plants in this crop selections of seed can be made for future general crops. If the crop during the second season shows uniformity of a desirable type, it is advisable to save a large quantity of seed under bag—if possible, sufficient to plant several succeeding crops—in order to provide for a possible failure of seed production in future seasons. Inasmuch as tobacco seed when properly cared for will retain its vitality for from 10 to 20 years, this seed can be safely used, if necessary, for 5 years. The best practice, however, is to save the seed for the following year's crop every season unless some accident should greatly injure the crop.

The grower of all new varieties of seed should test them on a small area before using them for his entire crop. In some cases new seed, when grown under conditions different from those under which the seed was produced, develops plants which are subject to fungous diseases or insect enemies in the new conditions. Therefore it is a wise plan to grow a small area of tobacco the first season and observe the plants carefully in respect to the presence of fungous or other diseases before using them in large fields. In other cases certain fungous diseases are present in the soil, which attack and destroy the varieties imported from other regions. In most cases resistant plants can be found in fields affected by these diseases. The structure or habit of growth of these resistant plants is such as to make them immune to these attacks. The seed of resistant plants should be saved under bag and used for the next year's planting. In this way resistant strains of tobacco which will prove to be immune to the attacks of the various diseases may be secured.

In selecting seed plants several important facts should be taken into consideration. All the plants in the field should be carefully studied and observations made on the shape of the leaf of the different plants, on the variations in size and color of leaves, and on the time of maturity of individual plants in the field.

Plate VIII, figure 2, shows two strains of Connecticut Broadleaf, the larger one from an early parent and the other from a late parent. The number of leaves and the number of suckers should be counted on many plants in the field from which seed is to be saved, in order that an accurate idea may be gained of the extent of variation in the variety as regards these points. As a rule, there is a great variation in all of the important characters which go to make up the type of plants, and individual plants will be found which have desirable shape, size, and color of leaf, which mature early and have an extra large

number of leaves and few suckers. The grower should decide in his own mind on the type of plant which he desires to grow for his crop and should carefully select those plants in the field which most nearly fulfill this ideal.

The flower head on the selected seed plants should be inclosed with a light but strong paper bag just before the flowers begin to open. The proper time to apply the bag is shown in Plate VII, figure 1, and the arrangement of bags is shown in Plate VII, figure 2. It is usually a good plan to remove two or three of the top leaves and suckers just below the flower head. The bag should be tied around the stem in such a way as not to interfere with the growth. It will be found that at this period of growth the plant increases in height very rapidly, and it will be necessary to raise the bag occasionally in order to prevent the flower head from pushing out through the bottom of the bag. For most varieties a 12-pound bag is the most desirable size. This bag should be of strong but light material. The ordinary paper bag found at any grocery store may be satisfactory for this purpose.

When the seed pods have turned brown, indicating maturity, the entire top of the plant should be cut off. The bag should be opened and all of the small and late pods picked off and only the large, heavy, plump, and well-developed seed pods allowed to remain. The bag should then be replaced and the seed head hung up in a dry place where there is a free circulation of air, such as the attic of a house, until the seed pods are thoroughly dried. After this the pods should be picked off from the stem and the seed shelled out. After the seed has been secured, all of the light seed, hulls, and chaff should be removed by the use of a seed separator, as shown in Plate IV, figure 1, or by some form of air-blast machine adapted for this purpose, and only the heavy seed should be retained for planting. The heavy seed should then be placed in dry glass jars and set in a safe place. In this condition the seed will retain its vitality unimpaired for a long period.

In many cases it may be desired to cross an imported with a native variety. The object of such crosses is to secure the improved quality of the imported strains, combined with the hardiness and yielding power of the native varieties. In the case of tobacco such crosses are easily made by the grower. The tobacco plant has a perfectly self-fertile and complete flower, but is easily cross-fertilized. In order to prepare the flower for cross-fertilization, the anthers should be removed from the selected flowers shortly before they open and discharge their pollen. The arrangement of the parts of the tobacco flower at different stages of maturity is shown in Plate VIII, figure 1. The opened flower in the lower right-hand corner shows the proper stage for the removal of the anthers. After an examination of a number of flowers in the field the grower can easily observe the proper time to remove the

anthers so that none of the pollen shall have escaped and fertilized the flower. One easy means of noting this time is to observe the condition of the corolla. The anthers should be removed just before the corolla opens. As soon as the anthers have been removed, a small paper bag should be tied over the flower and allowed to remain for at least one day or until the stigma becomes receptive for pollen. This receptive condition of the stigma is easily noted by the presence of a sticky, viscid substance over the surface. At the proper time for pollination, anthers from the desired imported strain which are just ready to discharge their pollen should be secured. These anthers should be broken open and the pollen carefully rubbed over the surface of the stigma of the flower to be fertilized. As soon as this pollination has been completed, the small bag should be replaced over the flower and allowed to remain there until the end of the season. A small tag should be attached to the flower, giving the name of both parents, as Havana × Sumatra (the first name referring to the female and the second to the male parent), with any other data which would assist the grower in keeping a record of the parentage of the cross.

The best plan which can be followed in the case of crosses is to grow 100 plants of each cross and carefully note the characteristics of the hybrid plants. It will be found that there will be considerable variation in the plants the first season. Seed should be saved from those plants which are most desirable and which show the greatest improvement over the native varieties. The next season a larger area can be planted from this seed; and if the crop is uniformly of the type desired, enough seed can then be selected the second season to plant the entire crop the third year.

HOW TO SECURE GOOD SEED.

1. Save the best plants in the field for seed plants. An early Broadleaf plant of desirable type is shown in Plate VIII, figure 2, in comparison with the ordinary plants, and was selected for seed production on account of earliness. During the cultivation of the crop and the suckering and topping processes a constant search for good plants should be made by growers.

2. When good plants are observed, they should be plainly marked by a tag or rag tied to the plant, so that they may be easily found and to prevent them from being accidentally topped.

3. Place a light, 12-pound size, manila paper bag over the flower heads of the selected seed plants before the first flowers open. Inspect the bags every few days for the first two weeks and raise them up farther on the growing stems, arranging them so as to prevent any injury from crowding in the bag during this period of growth. The extent to which this method of saving seed is now being followed is shown in Plate VI, figure 1.

4. At the end of the season, when the seed pods are ripe, cut off the plants near the ground without removing the bags and hang them up in a dry place. The bags serve to catch the seed which may fall out of the capsules on drying.

5. After the seed has thoroughly dried, shell it out of the capsules and separate the heavy seed for use by the means described in this paper.

6. It would be well for every grower using this method of seed selection to save some seed in the ordinary way and plant it for comparison.

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PLATES.

DESCRIPTION OF PLATES.

PLATE I. (*Frontispiece.*) Fig. 1.—Connecticut Cuban tobacco, first year from Cuba. Plants in foreground are freaks and undesirable. They have reached maturity prematurely, and have very few salable leaves. The suckers and flower branches are numerous and large. Fig. 2.—The same field shown in figure 1, after saving seed under bag and the selection of the best plants for two years. These plants have a large number of well developed, desirable leaves, with very few suckers or seed branches, as the result of careful seed selection.

PLATE II. Fig. 1.—Tobacco seed bed in Florida. This illustration shows plants just before transplanting. Note the uniformity of those grown from heavy seed. The bed, covering 2 acres, furnished enough plants for more than 100 acres of tobacco. Fig. 2.—Tobacco seed beds in Connecticut—tent, hotbed, and cold frame. The three best methods used for protecting tobacco seedlings in the North are shown. The beds in the center of the picture are covered with hotbed sash; the one on the right with cheese cloth raised about 12 inches above the surface of the bed; the one on the left is also covered with cheese cloth, arranged in the shape of a roof or tent and elevated sufficiently to allow men to walk about the bed without removing the cover. The glass cover seems to give the best results in most cases, and is conducive to the most rapid growth.

PLATE III. Fig. 1.—Transplanting tobacco seedlings with machine. The most satisfactory and practical transplanter is shown. By using this form of machine seedlings may be set in the field whenever they are of the proper size, and easily watered. Fig. 2.—Sterilizing soil for tobacco seed beds. This method is cheap and effective, and serves to kill all weed seeds, fungi, and insects that may be in the soil.

PLATE IV. Fig. 1.—Tobacco seed separator. This form of separator is an improvement over the one originally devised in the Laboratory of Plant Breeding of the Bureau of Plant Industry, and described in the Yearbook of the Department of Agriculture for 1904. Fig. 2.—Seedlings from heavy, medium, and light tobacco seed. The seed from which the seedlings shown were grown was taken from the same lot and planted at exactly the same time. Note the increased growth and vigor in plants grown from heavy seed.

PLATE V. Fig. 1.—Method of "spearing" tobacco plants during harvest. This shows the most practical and economical means of spearing plants with the least possible injury to the leaves. The plants are allowed to wilt very slightly before spearing. Fig. 2.—Wagon rack for transporting plants to curing shed. The group of seed plants in the background shows lack of selection under the old practice.

PLATE VI. Fig. 1.—Capped plants saved for seed. The ordinary manila paper bag of the 12-pound size was used in capping these plants. The bag should be made of a thin grade of paper. Fig. 2.—Curing shed in the Connecticut Valley. The superior value of this form of curing shed is largely due to the large number of ventilators which may be opened to admit air when needed in properly curing tobacco.

PLATE VII. Fig. 1.—Seed plant ready for bag. In preparing the seed plant for bagging, as shown, the small leaves and suckers just below the seed head have been removed to make room for the bag. Fig. 2.—Proper arrangement of bag on seed plant. When the bag is placed on the flower head of the seed plant, as shown, it should be tied rather loosely around the stalk, to allow for its proper development.

PLATE VIII. Fig. 1.—Arrangement and structure of tobacco flowers. The structure of the flowers, as shown, gives evidence of the fact that tobacco flowers are naturally self-fertile. Fig. 2.—Two strains of Connecticut Broadleaf tobacco, the row on the left from an early parent and the row on the right from a late parent. The plant on the right of the center of the picture, from a late parent, is representative of the entire plat.

PLATE IX. Fig. 1.—Uniformity in time of maturity and other characters of two types of Connecticut Sumatra tobacco raised from seed saved under bag. This striking uniformity is due to three years of careful seed selection and protecting the flowers from cross-pollination. Each row represents a different strain of the tobacco. Fig. 2.—Lack of uniformity in time of maturity and other characters in ordinary Connecticut Broadleaf tobacco, where seed was not saved under bag.

FIG. 1.—TOBACCO SEED SEPARATOR.

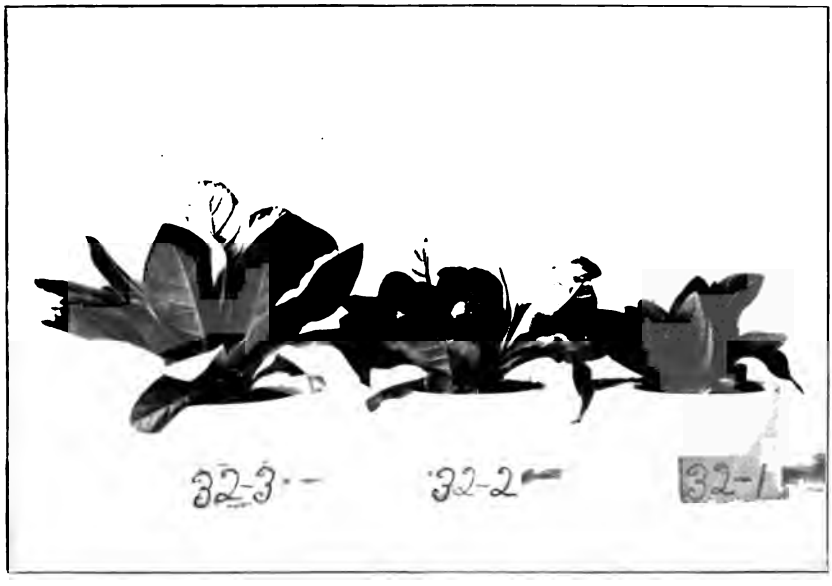

FIG. 2.—SEEDLINGS FROM HEAVY (32-3), MEDIUM (32-2), AND LIGHT (32-1) TOBACCO SEED.

FIG. 1.—CAPPED PLANTS SAVED FOR SEED.

FIG. 2.—CURING SHED IN THE CONNECTICUT VALLEY.

FIG. 1.—SEED PLANT READY FOR BAG.

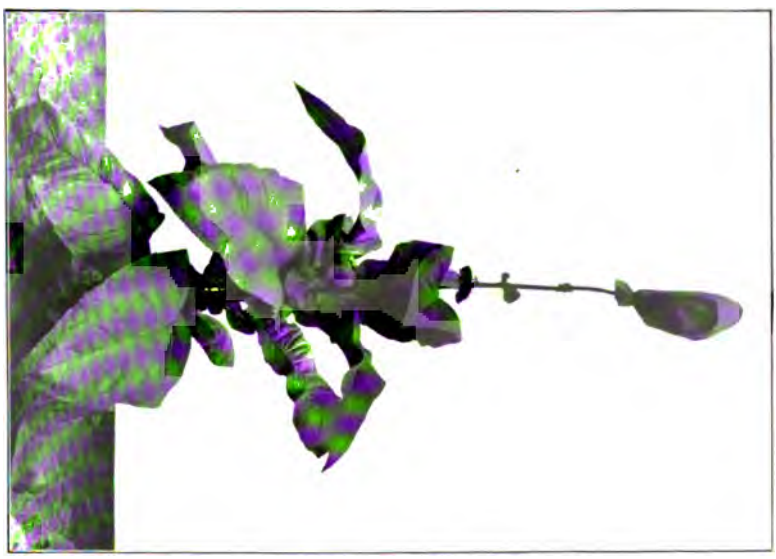

FIG. 2.—PROPER ARRANGEMENT OF BAG ON SEED PLANT.

FIG. 1.—ARRANGEMENT AND STRUCTURE OF TOBACCO FLOWERS.

FIG. 2.—TWO STRAINS OF CONNECTICUT BROADLEAF TOBACCO; THE ROW ON THE LEFT FROM AN EARLY PARENT, AND THE ROW ON THE RIGHT FROM A LATE PARENT.

Bul. 91, Bureau of Plant Industry, U. S. Dept of Agriculture.

FIG. 1.—UNIFORMITY IN TIME OF MATURITY AND OTHER CHARACTERS OF TWO TYPES OF CONNECTICUT SUMATRA TOBACCO RAISED FROM SEED SAVED UNDER BAG.

FIG. 2.—LACK OF UNIFORMITY IN TIME OF MATURITY AND OTHER CHARACTERS IN ORDINARY CONNECTICUT BROADLEAF TOBACCO.

HARVESTING DEGLET NOOR DATES AT TOZER.

(From a photograph by F. Soler, Tunis.)

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U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 92.
B. T. GALLOWAY, *Chief of Bureau.*

DATE VARIETIES AND DATE CULTURE IN TUNIS.

BY

THOMAS H. KEARNEY,
PHYSIOLOGIST, PLANT BREEDING INVESTIGATIONS.

ISSUED SEPTEMBER 6, 1906.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., March 1, 1906.

SIR: I have the honor to transmit herewith, and to recommend for publication as Bulletin No. 92 of the series of this Bureau, the accompanying manuscript, entitled "Date Varieties and Date Culture in Tunis," by Thomas H. Kearney, Physiologist, Plant Breeding Investigations.

The importance of this bulletin lies in the fact that it presents a key to the principal varieties of date palms—the first available to Americans interested in this fruit. It gives, further, an accurate picture of the conditions under which profitable date culture is carried on in the northern edge of the Sahara, and can not fail to be of value to all prospective date growers.

Acknowledgment is made of the courteous cooperation uniformly extended to Mr. Kearney by the authorities during his stay in Tunis. The valuable assistance rendered him by M. Hugon, director of agriculture and commerce, and by MM. Chervin, Minangoin, and Tellier, of the direction of agriculture, as well as by the contrôleurs civils at Tozer, Gafsa, Sfax, and Gabes, and by the caids of Tozer and Kebili, should be especially mentioned. The hospitality extended by Captain Donau, commandant supérieur at Kebili, and the great service rendered by him to the Department of Agriculture in having collected, prepared, and forwarded to Tozer 175 offshoots of the best varieties found in the Nefzaoua, merit especial acknowledgment. Prof. Milton Whitney, Chief of the Bureau of Soils, and Drs. F. K. Cameron and L. J. Briggs, of that Bureau, obligingly cooperated in furnishing mechanical analyses of the soil samples collected and chemical analyses of the soil and water samples.

This paper has been submitted by the Botanist in Charge of Seed and Plant Introduction and Distribution, and was prepared as a result of Mr. Kearney's expedition to the oases of Tunis in search of new varieties of dates.

The illustrations which accompany this paper are considered essential to a full understanding of the text.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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DATE VARIETIES AND DATE CULTURE IN TUNIS.

INTRODUCTION.

During the autumn and winter of 1904–5, while traveling as agricultural explorer for the Office of Seed and Plant Introduction and Distribution, the writer, at the suggestion of Mr. W. T. Swingle, made two trips to the oases of southern Tunis in order to study the varieties of the date palm grown there and to secure offshoots of the more promising sorts for introduction into the United States. The first visit was made in October and November, the period when the fruits of most of the varieties are ripening and when the harvest is in full progress. On that occasion six weeks were spent in the more important oases, and a careful study of the chief varieties was made. This was considered an essential preliminary to selecting varieties for importation, as very little has been done by Europeans in studying the characters of the almost innumerable varieties of the date palm and in ascertaining the relative merits of the different kinds.

Nowhere, perhaps, does a greater number of promising varieties occur within a restricted area than in these Tunis oases, and the opportunity for comparison of widely differing types was an exceptionally good one. In the course of the investigations a collection of 97 samples, representing 93 distinct varieties, was obtained. Descriptions of 105 varieties were drawn up on the spot from freshly gathered fruits, and in many cases the characters of the palms themselves were noted. The fruits of 85 varieties were photographed in natural size, and photographs of the trees of 34 varieties were made.

Much information was obtained regarding the fruits of the different varieties, their size, appearance, sweetness, flavor, time of ripening, productiveness, and keeping qualities. The season chosen for the visit allowed the interesting process of harvesting the dates to be observed. Attention was also paid to the subjects of irrigation, cultural methods, and of saline or "alkali" soils in relation to the date palm.

As a result of the first visit to the oases, it was possible for the writer to decide upon the varieties that seemed most desirable for introduction into the southwestern United States. To procure these varieties a second trip to the region was made for the Office of Seed and Plant Introduction and Distribution in February, 1905, and three weeks were spent in collecting and packing the offshoots. In all about 700 offshoots, representing 56 varieties, were obtained, and it required a caravan of 90 camels to transport them to the railway.

The importation of so large a number of varieties was thought desirable, because it was recognized that date culture in the United States is still in the experimental stage, and it is impossible to foresee as yet what varieties will prove most satisfactory. It is quite possible that some of those which thrive best and are most esteemed in their native countries will not succeed with us. On the other hand, varieties that are less esteemed at home may develop valuable qualities when transplanted to this continent. Furthermore, in view of the great diversity of climate and soil existing in the parts of the United States where date culture is possible, it seems altogether probable that different kinds will be found adapted to different sections. In that case the existence at some few central points in the Southwest of large collections of varieties will prove to be of cardinal importance in the development of this promising industry.

For these reasons, an effort was made to secure a few suckers of every well-marked variety of any value, while, of course, especial endeavor was directed to securing a larger number of each of the finest and most highly esteemed sorts. In a few cases the latter aim was not realized, owing to the rarity of the palms and the reluctance of the natives to part with the suckers. Of the superb Menakher date, for example, one of the principal objects of the expedition, only nine offshoots could be obtained, and most of these were smaller than could be wished. Yet at least a few offshoots were imported of all but one variety of primary value, and only two or three of the varieties that were regarded as of secondary value are wanting in the collection. It might be added that at the time of writing (October 1, 1905) from 75 to 95 per cent of the palms imported from Tunis six months previously are showing signs of growth in the different plantations in Arizona and California.

The chief object of the present report is to furnish descriptions of the Tunisian varieties imported into the United States, so that they can be identified hereafter. It is recognized that owing to the large number of varieties that have been introduced during the past five years much confusion in regard to the identity of the different sorts is likely to arise unless some attempt is made to place their characters upon record. To this end a descriptive key has been

worked out, which it is believed will be found useful in identifying the Tunisian varieties. As nothing of the kind has heretofore been attempted so far as the date palm is concerned, it is hoped that, besides fulfilling its immediate object, this key will afford suggestions as to the characters that are most serviceable in distinguishing the varieties and will serve as a basis for future studies.

To supplement the descriptions contained in the key, each of the varieties imported is discussed under the headings "Varieties of primary importance," "Varieties of secondary importance," "Varieties of minor importance," and "Varieties imported but not included in the key," with respect to the quality of the fruit, time of ripening, productiveness, trunk and foliage characters, resistance to alkali, etc.

As an introduction to the study of the varieties, the important geographical and climatic features of the region are treated, together with the character of the water supply and the cultural methods in use.

CHARACTERISTICS OF THE REGION.

GEOGRAPHY.

The principal oases of southern Tunis, in which the date palm is the chief culture, form four distinct groups, the Jerid, the Nefzaoua, Gabes, and Gafsa, each group being separated from the others by wide expanses of desert. (See fig. 1.) Each group differs in many important features from the others, having its special peculiarities of climate, soil, and water supply, as well as its characteristic varieties of dates.

The Jerid is for us by far the most important group of oases, for there are found in perfection some of the finest varieties of the date palm in the world. It is the only part of Tunis in which the choice Deglet Noor dates are produced in large quantity for European markets, exporting annually from one and one-half to two and one-half million pounds of them. This report, therefore, deals chiefly with the Jerid oases. A brief account of each of the other groups is given in the present chapter, but the discussions of climate, water supply, soils, and culture of the date palm apply almost solely to the Jerid. When reference is made to some other region, it is especially designated.

THE JERID.

The name "Jerid" (French spelling, Djerid) is an abbreviation of "Beled-el-Jerid"—the "cities of date palms." The group consists of four oases—Nefta, Tozer, El Oudiane, and El Hamma—sep-

arated one from another by several miles of barren, sandy, or stony desert. They lie at the northern edge of the Sahara Desert, nestling at the foot of a line of cliffs that forms the north bank of the Shott Jerid. The Shott, which is about 68 miles long from west to east, is in winter a large, shallow salt lake, and in summer a mud flat, covered toward its center with a shining white crust of salt, much resembling, therefore, the Salton Sink in southeastern California. Its mean elevation is about 70 feet above sea level. Toward the northwest it opens into the Shott Gharsa, continued still farther westward as the

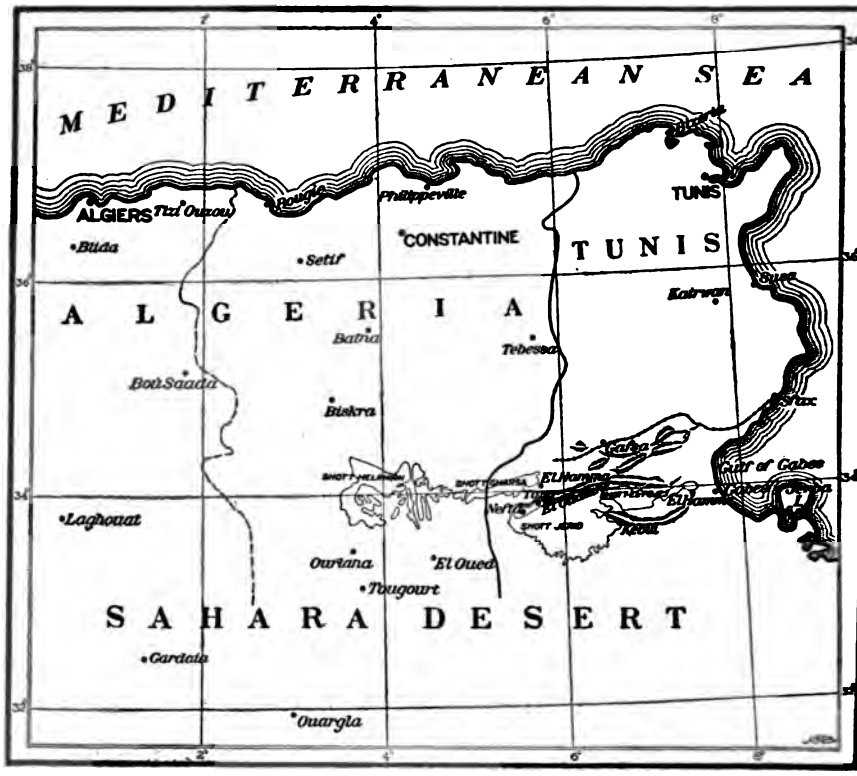

FIG. 1.—Map showing the location of the Tunis oases with respect to other localities in Algeria and Tunis.

Shott Melrhirh, which borders the Oued Rirh oases of Algeria.[a] Beyond the easternmost of the Jerid oases the Shott Jerid contracts into a strait, which connects it with the much narrower Shott-el-Fejej. The latter extends eastward to within a few miles of the sea, near Gabes.

Near its western end the Shott Jerid is bordered on the north by a barren, rocky line of bluffs of the pliocene formation, which farther

[a] See Bul. 80, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1905, p. 18.

east rises into the Jebel Sherb range of mountains. This escarpment, known as the Draa-el-Jerid, runs nearly east and west. West of Nefta it ends in a promontory extending between the Shott Jerid and the Shott Gharsa. It is virtually the southern edge of an arid, generally stony plain, almost devoid of vegetation, which extends northward to Gafsa and beyond, rising gradually into the elevated plateau of central Tunis. This plain is intersected by desolate ranges of hills and by deep ravines that contain water only at long, irregular intervals.

At the southern base of the Draa-el-Jerid bluffs, and sloping toward the Shott Jerid, lie the three oases of Nefta, Tozer, and El Oudiane, the first being the westernmost. Tozer is 15 miles east of Nefta and El Oudiane about 6 miles east of Tozer. These three oases are well sheltered from the north wind by the terrace behind them, but lie open to the south. On the other hand, El Hamma, 5½ miles north of Tozer, lies on the northwestern side of the Draa-el-Jerid, having the Shott Gharsa to the west, and while protected on the south and east sides it is much exposed toward the north and west.

In general aspect all four oases are much alike. They consist of almost unbroken forests of date palms, divided up into many gardens that are separated by mud walls and intersected by innumerable irrigation and drainage ditches. The total number of date palms in the region is variously estimated at from 600,000 to 1,000,000. It has been estimated [a] that the average annual production of dates in the Jerid is about 34,700,000 pounds, of which somewhat more than 5 per cent are of the Deglet Noor variety. (See p. 63.) Of the total product of other varieties, about one-third is consumed on the spot, the rest being exported to various parts of northern Africa.

In the shade of the palms (Pls. I; V, fig. 2, and VI) are grown many other kinds of fruit trees—oranges, olives, figs, apricots, peaches, pomegranates, and jujubes—interlaced with large grapevines that often hang in festoons from the palm trunks. Beneath the trees are small plots of garden vegetables, barley, and alfalfa. Neither date palms nor other trees are planted with any regularity, and the growth is often so dense that the garden resembles a tropical jungle.

Very beautiful are these gardens in the spring, when the apricot and peach trees are in blossom here and there among the palms and the figs and vines are putting forth their leaves. In autumn, when the dates are ripening, the color effects, especially when the tops of the palms are lit up by the last rays of the setting sun, are some-

[a] By Dollin du Fresnel, Le Djérid Tunisien. Bul. de la Soc. de Géogr. Comm. 22: 38 (1900).

thing that once seen can never be forgotten. The great clusters of fruit, displaying every tint from bright yellow, through orange, vermilion, and maroon, to plum purple and chestnut brown, with their brilliant yellow or rich orange ivory-like stalks, contrast superbly with the dull bluish or gray green of the feathery crowns of foliage. It is small wonder that a whole folklore of poetic legends and proverbs has grown up around the date palm in the regions where it flourishes.[a]

The oases, especially Nefta, were formerly much exposed to the encroachment of the wind-blown sand of the desert, but since the French occupation the forestry service has taken effective measures to protect them from this danger. Around each oasis, at a distance from the edge of the gardens generally of 1,000 feet, although varying according to circumstances, a mud wall, surmounted by a fence of palm leaves, has been erected. The sand drifts against this, forming an artificial dune sloping outward. As fast as this dune increases in height, the palisade is built higher. The slopes of the dune itself are planted with tamarisks, retam, and other desert shrubs suitable for binding the sand. The zone between the palisade and the gardens is strictly forbidden to the domestic animals that were formerly pastured there, as they kept the soil in a loose condition and prevented the growth of the natural vegetation that helps to hold it in place. At the most exposed points a series of outer palisades, erected at regular intervals, arrests a good part of the sand before it can reach the barrier which is nearest the gardens.

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[a] A number of these legends and beliefs are related by Charlet (Les Palmiers du Mzab, Bul. Soc. Géogr. d'Alger, 1905. Mohammed enjoined the care of the date palm as an almost religious duty, saying, "The palm is your aunt—the sister of your father Adam." He also spoke of the date as "the only fruit which has in heaven the same flavor as upon earth," and described in these glowing terms the palms that grow in paradise: "Trunks of gold, spathes of gold, branches of gold, leaves of gold, stalks of gold, petals of gold, fruits as large as buckets, softer than butter, sweeter than honey." Another Arab poet imagined thus the dates of paradise: "They will be whiter than milk, more transparent than honey, softer than butter; they will have no stones." The origin of the date palm is often the theme of Mohammedan writers. "When God had shaped Adam's body with his hands, a little of the earth which He had used to fashion in his image our first father stuck to his fingers. He rolled it between his hands, making from it the trunk of the palm." The Arabs profess to see many points of resemblance between the date palm and man, its friend and ally. "Like man, it holds up its head; like man, it has a companion of a different sex. Its heart (terminal bud), immaculately white, is as tender and delicate as the brain of a man, the least hurt causing its death. Like man, it fears cold. If one of its branches be cut off, it does not grow out again, and thus is like a man's limb. If one cuts off its head, it dies. The fiber (leef) that surrounds its head resembles human hair." The little circle, about 1.5 millimeters in diameter, that is found on the back of the stone is believed to be the impress of the seal of Solomon.

The Jerid region was evidently occupied by the Romans, and fragments of structures belonging to their epoch are frequently met with. Both Nefta (Nepte) and Tozer (Thusuros) are situated on or near the site of ancient Roman towns. Although frequently harried and pillaged by the nomadic Arabs and by other wild tribes of the desert, the oases of the Jerid have been, so far as we know, in a continuous state of cultivation throughout the Christian era. An Arab author of the eleventh century celebrated in glowing terms their fertility of soil and the beauty of their dense forests of date palms. "No other place in Africa," he wrote, "produces so many dates."

Until the completion of the railway from Sfax, on the east coast of Tunis, to the rich phosphate mines a few miles to the west of Gafsa (see map, fig. 1), the main artery of communication of the Jerid with the coast was the road, or rather trail, across the Shott Jerid, through the oases of the Nefzaoua, and then along the southern bank of the Shott-el-Fejej to Gabes, the total distance from Tozer to Gabes being about 120 miles. All the dates at that time exported from the Jerid to Europe had to be carried over this road by caravan. Now, however, Tozer is only about 35 miles from the end of the railway, and communication with the outside world is comparatively easy.

The total population of the Jerid oases is about 30,000, Tozer and Nefta each counting about 9,000 inhabitants. Practically this entire population is supported by date culture, as the other agricultural products of the oases are of so little importance as to be almost negligible and only a very small fraction of the population supports itself by manufacturing various fabrics.

Nefta, the most western oasis of the Jerid, is said to occupy over 6,000 acres. The number of date palms it contains is variously estimated at from 180,000 to 385,000, of which only 14,000 are said to be of the Deglet Noor variety.[a] The oasis consists of two distinct parts; on the north a deep basin, called by the French the "Corbeille" (basket), in which arise the springs that water the gardens, and on the south the fan-shaped larger portion, extending to the low salt flats that fringe the Shott Jerid. The town of Nefta (Pl. VI, fig. 3), the holy city of southern Tunis, lies between the two segments of the oasis and is itself separated into two parts by a deep ravine (shown in the foreground of Pl. VI, fig. 3). Through this ravine runs the stream that carries the waters of the springs from the "basket" to the lower part of the oasis. The palms that occupy the "basket" are of unusual beauty. It is said that a few years ago an English

[a] But by the same authority the total number of all kinds is given as only 180,000.

company made an unsuccessful attempt to purchase this part of the oasis.[a]

Better sheltered as it is than Tozer, especially on the north, and said to possess a more fertile soil, Nefta is well situated for date growing, and its palms yield fruit of high quality. Its gardens are celebrated for their beauty, containing many orange, apricot, fig, and other fruit trees, in addition to the date palms, which are largely of choice varieties. More vegetables, grain, and alfalfa (Pl. VII, fig. 2) are grown here than in the other oases of the Jerid. On the side toward the Shott new palm gardens are being established (Pl. VII, fig. 2) and are planted as far as possible to the Deglet Noor variety.

Tozer oasis lies about 15 miles east of Nefta. The oasis proper extends eastward and southward from the town of Tozer, which, like all the towns of the Jerid, occupies high, open ground outside the gardens. It is the political capital of the Jerid region. The elevation of the town above sea level is about 153 feet, but the oasis is several feet lower. The area of this oasis is variously given as 2,650, 5,400, and 7,400 acres, but it is probably larger than that of Nefta. Different authorities state the number of palms contained in this oasis at from 250,000 to 417,000, of which only about 14,000 are of the Deglet Noor variety. The gardens of Tozer differ from those of Nefta in the smaller development of subsidiary cultures. The chief fruit trees, other than date palms, are figs and pomegranates.

The oasis of El Oudiane begins about 5 miles east of the town of Tozer and extends for about 5 miles along the northern border of Shott Jerid, in a band that is from one-half mile to 2 miles wide. It lies so near the Shott that in winter the salt water sometimes rises nearly to the gardens. It is generally described as a group of five oases, but these are practically continuous, although each has its own village. The westernmost, known as El Degache, contains the finest gardens. The terrace, at the base of which the oases lie, is here much higher and closer to the gardens than at Tozer and Nefta, and El Oudiane is the best protected from the north wind of all the Jerid oases. Hence its dates, especially those of the Deglet Noor variety, are admitted on all sides to be the finest produced in the region.

There are estimated to be from 120,000 to 212,000 date palms in the El Oudiane oases. As 8,000 of these are said to be Deglet Noors, the percentage of that variety is considerably higher than in the other oases. Besides the magnificent date palms, there are about

[a] The "basket" of Nefta reminds one of the sunken gardens of the Oued Souf (Bul. 86, Bureau of Plant Industry), but is much larger than any of them

25,000 olive trees in the El Oudiane group, most of these being at Degache, where much oil is made for local use. There is also an abundance of other fruit trees, oranges, figs, pomegranates, apricots, grapevines, and even a few bananas. In fact, the gardens of El Oudiane are among the best kept and the most attractive in the Sahara. The population is more active and laborious than that of the other oases of the Jerid.

El Hamma, situated about 5½ miles north of Tozer, lies on the northwest point of the Draa-el-Jerid terrace, on the south declivity of which the other oases are placed. The oasis slopes westward to the Shott Gharsa, instead of toward Shott Jerid. It is practically unsheltered from the north wind, which is probably the chief reason why its dates are the poorest of the region. It contains only 60,000 or 70,000 palms, of which but 800 are Deglet Noors. With a few exceptions, the gardens of this oasis are neglected and have grown up in weeds and grass. Many of the palms receive no attention whatever, and many seedlings of inferior quality have been allowed to spring up. The population is sparse and seems to be thoroughly disheartened. Dates are said to mature less perfectly here than in the other oases.

THE NEFZAOUA.

The region known as the Nefzaoua occupies a narrow peninsula that is bounded on the south by the eastern end of the Shott Jerid and on the north by the Shott-el-Fejej. The latter, which is merely a prolongation of the former, extends eastward to within 14 miles of the coast, near Gabes. From Fetnassa, the northwesternmost oasis of the Nefzaoua group, to Kriz (El Oudiane), the nearest point in the Jerid, the distance is about 30 miles, the road leading diagonally across the salt-crusted mud flats of the Shott Jerid. From Kebili, the capital of the Nefzaoua (see map, fig. 1), to Gabes, on the coast, the distance is about 64 miles as the crow flies, the direction being a little north of east. By the road usually traveled, which follows the south shore of the Shott-el-Fejej, the distance is somewhat greater. Before the railway from Sfax to the phosphate mines west of Gafsa was built this road formed the principal outlet to the coast for the Jerid as well as the Nefzaoua oases. Along this route there are a few small oases, but no important ones are encountered until one nears Gabes.

The Nefzaoua comprises a large number of oases—more than 1,000, according to the estimates of reliable authorities. Most of these, however, are mere small groves of palms, only forty of them attaining any considerable size. They are situated both on the north and the south slope of the stony ridge that forms the backbone of the

peninsula. This ridge is the western extension of the desert mountain range known as the Jebel Tebaga, which forms the southern border of the Shott-el-Fejej. The oases that are on the south side of this ridge are naturally more sheltered from the north wind and better situated for the ripening of dates than those on the north side.

The population of the Nefzaoua is stated to be 25,000, distributed in 45 villages. The total number of date palms in the region is estimated by one authority to be 280,000, by another over 1,000,000. The first estimate is probably more nearly correct. It is a peculiarity of the Nefzaoua, which places it in strong contrast with the Jerid, that the oases are mostly situated upon the higher lands. The reason is that nearly all the springs are found craterwise at the summits of small volcano-like hillocks, and the gardens of date palms have grown up around them. The water supply is abundant, and owing to the situation of the springs with relation to the gardens irrigation is generally easy. In the oasis of Menchia, however, the gardens are generally some distance away from the springs, and water is conducted to them by means of tunnels that have been bored into the sides of the hills in which the springs rise. Some of these tunnels are said to have been constructed in the times of ancient Rome, this region also having been occupied by the Romans. In the Nefzaoua, as in the Jerid, the water sheet is located in cretaceous strata.

Menchia is the most important of the oases on the north side of the ridge. Its soil is sandy and contains much gypsum, but not an excessive amount of the more readily soluble salts. On the south slope the oasis which pertains to the two villages of Tlemine and Mansourah is the largest, and its gardens are the best kept of the region. It is said to contain 29,000 palms, while the next largest oasis, Kebili, contains 20,000. In these two oases the soils are generally excellent, although frequently a trifle salty.

The culture of the date palm is generally given less care in the Nefzaoua than in the Jerid. Many of the gardens have been allowed to grow up in seedlings of poor quality and are almost choked with weeds. The Deglet Noor variety has not heretofore been grown in the Nefzaoua, although the conditions would appear to be perfectly suitable for it. Recently the forestry service has taken some steps toward establishing its culture in some of the oases. The growing of other fruit trees and of crops of vegetables, cereals, and forage plants among the palms receives much less attention than in the Jerid. A great deal of trouble has resulted from the incursion of wind-blown sand, and here, as in the Jerid, the forestry service has had to undertake the protection of the oases by constructing palisades and by prohibiting the pasturing of animals on the outskirts of the gardens.

South of Kebili there is a region of sand dunes, and here the palms, according to M. Minangoin, inspector of agriculture, are grown in sunken gardens, similar to those of the Oued Souf region,[a] but on a smaller scale. In the oasis of Douz, about 16 miles south of Kebili, this form of date culture reaches its highest development in Tunis. There basins among the dunes are excavated to a depth of about 13 feet and often 100 to 130 feet square (the sand being carried out in baskets) in order to plant a dozen or so palms and a few other fruit trees. The palms grown with such an enormous expenditure of labor almost always belong to inferior varieties. During several months of each year most of the population of this oasis migrates in search of pasturage for its flocks. Upon the return of the inhabitants they must immediately set to work to clear out the sand that has invaded their gardens, a task that requires nearly as much labor as the original excavation.

GABES.

In extreme southern Tunis the Sahara Desert practically reaches the seashore, forming the region known as the "Aarad." One of the largest and most flourishing groups of oases in the country is that which has for its center the seaport town of Gabes. These oases are well supplied with water, those nearest Gabes chiefly by means of a series of little dams in the Oued Gabes (Gabes River) and its branches, the more distant ones from springs and wells. The large oasis of El Hamma—of the same name as one in the Jerid region—is famous for its hot springs. This oasis has an area of about 4,000 acres, and the combined area of those nearer Gabes is said to be about the same.

About 400,000 date palms are estimated to exist in the oases of Gabes and El Hamma together. At Gabes the humidity, due to the proximity of the sea, prevents the successful growing of the finer varieties, notably the Deglet Noor. While the date palm itself thrives admirably in the Gabes region, and a great number of varieties exist there, the fruit produced is far inferior in flavor and sweetness to that of the Jerid and the Nefzaoua. Moreover, it is said not to keep well and easily to become moldy. The same criticism applies to the dates grown on the neighboring island of Jerba, where also there are about 400,000 palms.[b] But at El Hamma, although only 15½ miles inland, the quality of the dates is appreciably better.

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[a] See Bul. 86, Bureau of Plant Industry, U. S. Department of Agriculture, 1905.

[b] It is interesting to know that some kinds of dates can be ripened on the seacoast, even considerably farther north than Gabes. M. Minangoin, inspector of agriculture at Tunis, in a letter to the writer, describes a small oasis of 4,000 to 5,000 palms, situated on a sand spit near Susa (Sousse), about 120 miles north of Gabes. Two kinds of dates are grown, of one of which the fruits must be eaten the day they are gathered, while the other kind can be kept for only

In respect to other cultures, however, Gabes is easily first among the Tunis oases. Garden vegetables grow to perfection beneath the palms and mature so early that were there better facilities for transportation there would be a large profit in shipping them to European markets. Alfalfa grows beautifully and gives a rapid succession of cuttings throughout most of the year. Large yields of barley are obtained. Fruit trees of various kinds, but especially figs and pomegranates, are abundant and produce fruit that is highly esteemed throughout Tunis. Gabes is celebrated for the production of a small, deliciously flavored banana that is exported in some quantity to Europe. The grapevine grows to enormous size, and individual vines that produce 330 pounds of fruit are said to be not uncommon. Notwithstanding the scanty rainfall, plantations of oil olives in land that is not irrigated, similar to those of Sfax, are being established on the outskirts of some of the oases.

GAFSA.

The town of Gafsa is situated about 50 miles northeast of Tozer, the capital of the Jerid, and is connected with Sfax, on the east coast of Tunis, by a railway about 125 miles long. The elevation of Gafsa above sea level is about 1,150 feet. Tributary to the oasis of Gafsa itself are one or two other oases of small importance. Gafsa oasis contains from 50,000 to 65,000 date palms. These belong mostly to inferior varieties, and the dates produced are of mediocre quality. Because of its much greater elevation this locality is entirely unsuited to choice varieties, such as the Deglet Noor. The water supply is more than ample for the present extent of the oasis. The date is here hardly a more important crop than the olive, of which there are many thousands of trees. Oil varieties predominate. At the beginning of the Christian era Gafsa (then known as Capsa) was included in the great olive zone that extended from the east coast of Tunis across into Algeria, and of which only scattered fragments remain.

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four or five days. These must be picked from the bunches as fast as they ripen, which necessitates climbing each palm every day until all of its product is harvested. These dates are sold in the markets of Susa at a rather high price, as they ripen at a time when other fresh fruit is not obtainable. They are eaten only by the natives, Europeans holding them in small esteem. The high value set upon them by the natives is shown by the fact that the offshoots are sold at a price of $2 apiece. While the two varieties grown at this locality are doubtless of little intrinsic value, it is remarkable that dates of any sort will mature under these climatic conditions; for at Sfax, where the summers are slightly hotter than at Susa, the normal sum total of mean daily temperatures from May 1 to October 31 is only 1,968° F., and the normal sum of mean daily maxima during the same period is only 3,375° F.

At the present time the culture of the olive as carried on at Gafsa leaves much to be desired, and the gardens are generally not well cared for. The pomegranates of Gafsa are considered the best grown in Tunis.

CLIMATE.

The climate of southern Tunis is essentially that of a desert, although modified by the nearness of the sea. This modification is, of course, most marked at Gabes, on the coast, which has a more humid atmosphere and lower summer temperatures than the other oasis groups, and is consequently not well adapted to the culture of the finest varieties of dates. At Gafsa the air is drier than at Gabes, but the high altitude (1,000 feet) lowers the temperatures and shortens the summer to a degree that renders this oasis unsuitable for the late-ripening varieties. Only in the Jerid and the Nefzaoua oases do we find the climatic conditions that are necessary for the perfect ripening of the finest sorts of dates.

TEMPERATURE.

In the following tables data are given for five localities in Tunis where the date palm is the principal culture, viz, Tozer and Nefta (Jerid), Kebili (Nefzaoua), Gabes, and Gafsa. The normals for the different localities and for different months have been compiled from records of observations covering periods of unequal length, being from nine to thirteen years at Tozer. The monthly normals for Gabes and Gafsa have been corrected so as to agree with the normals of fifteen years for each season (winter, spring, summer, and autumn).[a] All temperatures are given in degrees Fahrenheit.

[a] As given by G. Ginestous (Etude sur le Climat de la Tunisie, Bul. Dir. Agr. et Com., Tunis, 1902, pp. 64, 210, 334, 413; 1903, p. 103). The discrepancy between the seasonal normals given by this author and the monthly normals compiled from various sources is usually only a fraction of 1 degree Fahrenheit for each month, although sometimes amounting to 3 or 4 degrees. The monthly normals have been compiled from the records published in the Annales du Bureau Central Météorologique de France and in the quarterly Bulletin de la Direction de l'Agriculture et du Commerce de Tunis. Those for Nefta and Kebili, localities for which seasonal normals are not given by Ginestous, are based upon short periods of observation, in no case exceeding six years, and in some cases of only three years, although generally four or five years.

TABLE 1.—*Normal mean temperatures of localities in the desert regions of Tunis, Algeria, and the United States.*

Month.	Tunis.					Algeria.			United States.		
	Tozer.	Nefta.	Kebili.	Gabes.	Gafsa.	Biskra.	Tougourt.	Ouargla.	Phoenix, Ariz.	Yuma, Ariz.	Volcano Springs, Cal.
January	51.3	50.5	49.6	51.8	49.2	50.5	47.3	46.8	49.8	54.1	55.9
February	55.9	56.3	56.5	55.6	53.7	58.2	49.8	51.8	54.3	58.6	60.5
March	62.1	61.1	61.7	59.7	58.1	58.3	54.9	59.9	58.9	63.9	68.4
April	68.7	69.2	71.9	64.2	64.2	63.1	64.0	66.4	67.0	69.9	79.7
May	76.1	74.5	74.8	69.2	71.4	71.8	74.8	73.6	74.4	76.9	87.5
June	86.2	84.3	84.1	76.3	80.4	80.6	86.0	82.4	83.9	84.4	96.6
July	92.0	89.1	89.4	81.3	85.6	87.1	92.1	90.7	90.2	91.2	101.3
August	92.0	88.8	87.0	81.0	85.4	85.8	85.1	86.0	88.2	90.4	99.7
September	83.1	83.8	82.5	80.0	81.7	78.8	83.7	78.1	81.4	84.3	89.5
October	73.0	72.9	72.5	72.8	71.3	67.6	68.4	63.5	69.3	72.4	78.4
November	61.7	61.4	59.8	62.9	59.8	57.2	58.5	52.9	58.5	62.3	67.0
December	52.3	53.0	52.0	54.3	48.6	51.3	48.9	45.0	52.3	55.9	57.4
Year	71.2	70.4	70.1	67.4	67.4	67.1	67.8	66.4	68.6	72.0	78.5

Comparing the Tunis localities among themselves, we notice that during most of the year the Jerid oases (Tozer and Nefta) are the warmest, and that next to them is the Nefzaoua (Kebili). In November, December, and January, however, the highest means are reached at Gabes, on the seacoast. The normal yearly means are higher in the Jerid and the Nefzaoua than in any of the Algerian oases. The difference is particularly noticeable during the winter months, when the means are decidedly lower in the Algerian oases than in those of the Jerid and the Nefzaoua. The normal means of most months are higher in the Jerid and Nefzaoua oases than at Phoenix, Ariz., but lower than at Yuma, Ariz. They are much lower in every month than at Volcano Springs, Cal.

TABLE 2.—*Normal mean maximum and minimum temperatures of localities in the desert region of Tunis.*

Month.	Mean maxima.					Mean minima.				
	Tozer.	Nefta.	Kebili.	Gabes.	Gafsa.	Tozer.	Nefta.	Kebili.	Gabes.	Gafsa.
January	59.4	63.7	57.9	62.7	59.5	42.8	37.7	39.2	40.7	39.5
February	65.5	70.0	65.8	67.6	66.2	46.5	41.3	41.9	43.6	39.3
March	72.5	76.1	72.5	71.3	70.4	52.3	47.3	48.2	48.6	44.6
April	81.3	86.5	84.4	76.0	80.7	56.8	54.1	56.8	53.5	49.9
May	89.1	84.0	88.3	78.9	85.2	65.3	60.2	60.2	58.0	56.3
June	99.7	99.2	96.9	85.3	96.5	74.1	69.2	68.2	67.2	63.9
July	107.1	104.9	103.8	90.8	102.8	77.6	73.2	73.4	71.0	69.7
August	104.6	103.8	101.3	91.4	101.2	79.5	74.4	72.2	71.3	69.1
September	93.7	98.3	95.1	91.9	96.2	72.5	69.5	69.8	71.0	66.0
October	83.2	86.1	82.6	83.6	84.0	63.1	58.1	60.6	61.5	57.3
November	70.5	76.1	70.6	73.3	75.0	53.2	50.5	48.2	50.5	47.2
December	60.3	71.0	61.1	65.6	60.2	44.7	40.1	42.4	44.2	37.7
Year	82.2	85.4	81.7	78.2	81.5	60.7	56.3	56.8	56.8	53.4

As is shown by the foregoing table, the normal yearly maxima are highest in the Jerid oases (Tozer and Nefta) and are lowest at Gabes, on the coast. In winter the maxima are higher at Nefta,[a] but lower at Tozer than at Gabes. At Tozer the minima are higher for nearly every month than at any other locality in Tunis, while at Nefta those for June, July, and August are higher than at any other locality excepting Tozer. Comparing Gafsa, which has an elevation above sea level of 1,000 feet, with Gabes, on the coast, we find the maxima higher at the former point in all seasons except winter. The minima are lower at Gafsa than at Gabes in every month of the year.

A climatic factor upon which the success of date culture largely depends is the sum total of heat received during the ripening period, which can be taken as comprising the six months from May 1 to October 31. As it is still a question whether the sum total of the daily means or those of the daily maxima give the best expression of this factor, both sums have been computed for the Tunis localities, and are given in the following table. Following the suggestion made by Mr. W. T. Swingle,[b] the sums of the daily means are based upon the excess of the normal monthly means over 64.4° F., while in computing the sums of the daily maxima above 64.4° deduction has been made for normal monthly minima that fall below that temperature.

[a] As pointed out on p. 21, however, the results for Nefta and for Kebili are based upon too short periods of observations.

[b] Bul. 53, Bureau of Plant Industry, pp. 65–68.

TABLE 3.—*Sums of daily mean and daily maximum temperatures above 64.4° F. from May 1 to October 31, at localities in the desert regions of Tunis, Algeria, and the United States.*[a]

Locality.	Sum of daily mean temperatures.	Sum of daily maximum temperatures.	Period covered by observations.	Remarks.
Tozer, Tunis	3,555.5	5,818.5	9 to 13 years	All varieties, including Deglet Noor, ripen perfectly.
Nefta, Tunis	3,277.7	5,710.4	3 to 6 years	Do.
Kebili, Tunis	3,183.1	5,357.6	4 to 5 years	Several first-class varieties ripen perfectly. Deglet Noor not yet grown.
Gabes, Tunis	2,272.7	3,936.5	15 years	Finest varieties do not ripen well: even second and third class dates do not always ripen perfectly.
Gafsa, Tunis	2,738.1	4,943.9	do	Too cold to mature the finest varieties.
Biskra, Algeria	3,304.0	5,489.0	10 years (means), 12½ years (maxima).	Many varieties ripen perfectly, but the Deglet Noor is generally unsatisfactory.
Ayata, Algeria	3,488.0	5,932.0	3 years (means), 4 years (maxima).	Deglet Noor ripens well in hot summers, imperfectly in cool summers.
Phoenix, Ariz	3,019.0	5,523.0	Many years (means), 4 years (maxima).	Many varieties ripen well, but not the Deglet Noor.
Salton, Cal	4,823.0	7,306.0	12 years (means), 2 average years (maxima).	Dates not grown.

It would appear that for purposes of comparison of different localities as to their suitability for the culture of fine varieties of dates the sums of the daily maximum temperatures are more satisfactory than those of the daily means. For at Biskra, Algeria, where the Deglet Noor seldom ripens properly, the normal sum of the daily means is higher than that given above for Nefta, and only 250 degrees lower than at Tozer, yet at both of these Tunis localities the Deglet Noor rarely fails to mature, while the normal sums of the daily maxima both at Tozer and at Nefta are considerably higher than at Biskra. Furthermore, at Ayata, Algeria, in 1891, when Deglet Noor dates ripened "very slowly and imperfectly," the sum of the daily means was 3,431, or only 124 degrees lower than the normal for Tozer as given in the table. But in favor of the sum of the means rather than of the maxima is the fact that at Ayata, where the Deglet Noor does not ripen well every season, the normal sum of the maxima is nearly 100 degrees higher, while that of the means is about 70 degrees lower than at Tozer. At Phoenix, Ariz., where the Deglet Noor will probably not mature, the sums of daily mean and daily maximum temperatures are several hundred degrees lower than at Tozer. At Salton, Cal., however, both

[a] The sums for Biskra and Ayata, Algeria, and for Phoenix and Salton, in the United States, are those given by Swingle, Bul. 53, Bureau of Plant Industry, pp. 66 and 68. As explained by Mr. Swingle, the method of observing temperatures formerly used at Salton has probably made the sum for that point appear to be higher than is actually the case.

sums are so very much higher than at Tozer that, even when we make a considerable allowance for the probable overestimate, due to the way the observations have been taken at Salton (see p. 24), we can not doubt that the Salton Basin is hot enough for the perfect ripening of all the Tunis varieties of dates. At Gabes, on the coast of Tunis, only second or third rate varieties are grown, and even these often fail to mature well, as would be expected from the low sums of temperature (much lower than at Tucson, Ariz.). At Gafsa, also, where the sums of the daily mean and daily maximum temperatures are, respectively, nearly 300 and nearly 500 degrees lower than at Phoenix, none of the first-class varieties can be successfully grown.

A comparison of the weather of several successive years at Tozer during the six months that are most decisive in the ripening of dates, with statements of the character of the succeeding crops, is presented in the following table:

TABLE 4.—*Climatic conditions and character of date crop at Tozer, 1901 to 1905.*

Year.	Sum of means, May to October.	Sum of maxima, May to October.	Rainfall, May to October.	Character of crop.
1901	3,459	5,335	May 0.87 June July August September 1.07 October .84 2.78	Yield not stated. Quality lowered by September rains, especially inferior sorts, which contained many worms.
1902	3,899	5,922	May June July August September 0.64 October 1.78 2.42	Crop very large, but quality somewhat injured by autumn rains.
1903	3,309	5,793	May June July August September 0.93 October .93	Crop much smaller than in 1904.
1904	3,719	5,622	May June July August 0.08 September .13 October .13 .34	Crop very large and of excellent quality.
1905	3,565	5,643	May 0.17 June .75 July .11 August September October .40 1.43	Harvest retarded until October 23-26. Dates ripened imperfectly.

Judging by the data for 1904, the period of the writer's visit, when the crop was admitted on all sides to be an unusually fine one, both as to the quality and quantity of the fruit, it would seem

as if the sum of the daily means, which in 1904 was more than 150 degrees higher than the normal, were a more satisfactory basis for comparing one season with another at the same locality than the sum of the daily maxima, which was about 200 degrees lower than the normal. Furthermore, in 1905, when the ripening of the dates was late and imperfect, the sum of the daily means was nearly normal, while that of the daily maxima was again nearly 200 degrees lower than the normal. In 1903, when the crop was much smaller than in 1904, the sum of the daily maxima was only 25 degrees lower than the normal, while the sum of the daily means was nearly 250 degrees below the normal. Still more conclusive are the data for 1902, a year when the crop was unusually large. The sum of the daily maxima of that season was only 100 degrees higher, while that of the daily means was 350 degrees higher than the normal.

TABLE 5.—*Mean maximum and minimum temperatures at Tozer during the months of May to October, 1904 and 1905.*

Year.	May.		June.		July.		August.		September.		October.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1904	90.8	65.3	89.2	75.7	104.7	85.4	108.7	84.4	96.2	73.7	83.1	61.3
1905	89.4	63.5	98.2	72.7	105.0	80.0	104.3	79.7	97.3	75.9	78.6	62.8

Comparing further the good year 1904 with the poor year 1905 at Tozer, we find that while the mean maximum was much higher in June and slightly higher in July in the latter year, the August and October maxima were considerably higher in 1904, while those for May and September differed little in the two years. The mean minima during the first four months of the season were considerably higher in 1904 than in 1905.

ATMOSPHERIC HUMIDITY.

The amount of moisture in the air is an important factor in date culture. At Gabes, in Tunis, one of the few localities in the world where the date palm is extensively grown on the seacoast, the quality of the fruit is often seriously impaired by this cause (see p. 19). In the following table the mean relative humidity for each of the four seasons and for the year is given for several localities in North Africa, where date culture exists, and for localities in the southwestern United States, where it can probably be successfully introduced.

TABLE 6.—*Mean relative humidity at localities in the desert regions of Tunis, Algeria, and the United States.*

Season.[a]	Tunis.			Algeria.		United States.
	Tozer.	Gabes.	Gafsa.	Biskra.	Ouargla.	Yuma.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Winter	70.6	70.1	64.0	59.8	48.5	46.9
Spring	63.0	65.0	57.6	47.7	46.4	38.3
Summer	52.0	64.1	47.0	34.9	30.1	41.7
Autumn	59.6	67.6	59.6	51.3	47.6	44.7
Year	61.3	66.7	57.0	48.4	43.1	42.9

[a] Winter comprises December, January, and February; spring, March, April, and May; summer, June, July, and August; and autumn, September, October, and November.

As shown by the above table, the Tunis oases have at all seasons a decidedly more humid atmosphere than those of Algeria. At Yuma the air is drier than at any of the North African localities, except in summer, when Yuma is more humid than Biskra and Ouargla. Comparing the three Tunis localities one with another, we find that at most seasons the humidity is greatest at Gabes, as would be expected from its situation on the coast, and least at Gafsa, which lies in the midst of extremely arid elevated plains and is cut off from the sea by ranges of desert mountains. Tozer in winter is slightly more and in spring little less humid than Gabes, but in summer and autumn it is decidedly drier. All things considered, the humidity at Tozer is surprisingly higher for a locality where the finest kinds of dates are produced.

PRECIPITATION.[a]

TABLE 7.—*Normal precipitation, in inches, at localities in the desert regions of Tunis, Algeria, and the United States.*

Season.	Tunis.				Algeria.			United States.		
	Tozer.	Nefta.	Gabes.	Gafsa.	Biskra.	Tougourt.	Ouargla.	Phoenix, Ariz.	Yuma, Ariz.	Volcano Springs, Cal.
Winter	1.7	1.4	2.8	2.4	2.1	2.0	1.4	2.3	1.3	1.1
Spring	2.4	2.1	1.9	3.4	2.2	1.6	1.4	1.0	0.4	0.1
Summer	0.1	0.2	0.1	0.6	0.6	0.1	0.1	2.0	0.5	0.2
Autumn	0.7	0.7	2.7	1.9	1.8	1.3	0.7	1.5	0.6	0.2
Year	4.9	4.4	7.5	8.3	6.7	5.0	3.6	6.9	2.8	1.6

The total annual rainfall of the Jerid oases (Tozer and Nefta) is very much less than that of Gabes, on the coast of Tunis, and of Gafsa, which has an elevation of 1,000 feet above sea level. Tozer

[a] The relation of the rainfall of the Tunis oases to date production is discussed under the heading "Ripening," on pp. 51 and 52 of this bulletin.

has about the same total precipitation as Tougourt, in Algeria, considerably more than Ouargla, Algeria, and considerably less than Biskra, Algeria, and Phoenix, Ariz., the last two localities having nearly the same total. The Colorado River Valley and the Salton Basin in the United States receive considerably less rain than any of these North African localities. Regarding the distribution by seasons, we find that nearly one-half of the total precipitation falls in spring in the Jerid oases, a larger proportion than at any of the other localities given in the table. The autumnal precipitation is relatively smaller at Tozer and at Nefta than at any of the other localities excepting Volcano Springs, Cal. At Phoenix and Yuma, Ariz., the rainfall in summer forms a much higher proportion of the total for the year than at any of the other points included in the table.

IRRIGATION AND DRAINAGE.

As the water supply and irrigation conditions of the oases of the Nefzaoua, Gabes, and Gafsa have been briefly discussed under the heading "Geography," only the Jerid region will be treated in this place.

WATER SUPPLY.

The oases of the Jerid, unlike those of the Oued Rirh, in Algeria,[a] are watered by means of springs instead of wells. This is explained by the fact that the Jerid oases are situated at the very base of the terrace that marks the northern frontier of the desert, while the Oued Rirh group lies well into the Sahara. Attempts to obtain artesian water in the Jerid region have so far been unsuccessful.

The springs of the Jerid are all situated at about the same elevation—135 to 150 feet above sea level. They originate in strata of cretaceous formation at the base of the line of bluffs. As the springs are very numerous and in many cases very large, maintaining a practically constant flow throughout the year, it seems unlikely that the scanty rainfall of the region itself can account for the abundance of the water supply.[b] The general temperature of the water as it issues from the ground is about 86° F., and varies little from season to season.

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[a] See Bul. 53, Bureau of Plant Industry, U. S. Dept. of Agriculture, pp. 44–46, where the irrigation of the date palm in the Algerian Sahara is described; also, Bul. 80, Bureau of Plant Industry, pp. 36–38, where this subject is discussed.

[b] Rolland, Hydrologie du Sahara Algérien, pp. 182, 183, holds that the water which feeds the springs of the Jerid must constitute an artesian sheet, derived largely from the eastern spurs of the Aurès Mountains and flowing deep under the elevated plain which abuts on the shotts of southern Tunis. On the other hand, Doumet-Adanson (Sur le régime des eaux qui alimentent les oasis du Sud

The oasis of Nefta is supplied with water by a large number of springs that arise in the "Corbeille," or "basket" (p. 15). Their combined flow, amounting to about 292 gallons (1,100 liters) per second, gives rise to the stream which waters the southern part of the oasis. This quantity of water is estimated by Rolland to be sufficient for irrigating the entire oasis at the rate of about 2 acre-feet per acre annually.

Taking as the number of date palms existing at Nefta the mean of the two estimates given on page 15, we should have 282,500 trees. If the total supply furnished by the springs were divided equally among them, each would receive about 0.24 quart per minute,[a] or about 86 gallons per day. As it has been calculated by Rolland that to give the best results each date palm should be allotted at the source of supply 0.53 quart (0.5 liter) per minute (hence about 190 gallons per day)[b] it is evident that the supply available is not sufficient for the perfect irrigation of more than one-half of the date palms of the oasis.

The 140 springs that supply the oasis of Tozer with irrigating water give rise to a stream that delivers about 278 gallons (1,050 liters) per second; hence about 3,200,000 cubic feet daily. This quantity is estimated to suffice for irrigating the oasis at the rate of about 1.5 acre-feet per acre annually. Assuming that there are 385,500 palms (the mean of the two estimates given on page 16) in this oasis, and making the calculation upon the same basis as for Nefta, the share of water at the source of supply available for each tree would be only 0.17 quart per minute, or 62.4 gallons per day, which is less than one-third the amount (0.53 quart per minute) estimated by Rolland as the optimum.[c] It should be noted, however, that the distribution of water among the different parts of the oasis is very

de la Tunisie, Assoc. Franç. Avancem. Sciences, 1884, p. 72) regards the infiltration water drained through the sands of the adjacent region as sufficient to supply these springs. He does not consider the water sheet to be of artesian character.

[a] Rolland, assuming that there were 201,100 palms at Nefta, calculated that there should be available for each, at the source of supply, 0.33 liter (0.35 quart) per minute. In his, as in the writer's calculation, no deduction is made for the amount of water lost to the palms through seepage and evaporation from the ditches, growing of other crops, and use by the inhabitants and their domestic animals.

[b] See Bul. 53, Bureau of Plant Industry, p. 45.

[c] A much lower estimate has been made by M. Minangoin, inspector of agriculture at Tunis, of the amount of water theoretically available for each date palm in the oasis of Tozer. He states that the combined flow of the 140 springs is only 1,700,000 (instead of 3,200,000) cubic feet daily; and assuming that there are 300,000 trees in the oasis, he arrives at the figure of 42 gallons (160 liters) as representing the amount available at the source of supply for each palm daily.

unequal, the palms in some gardens being amply and even superabundantly irrigated, while thousands of trees receive no irrigation whatever, except by seepage.[a]

There is some indication that the flow of the springs at Tozer is diminishing in volume. It would appear also that there has been a gradual lowering of their level, due to the progressive cutting down of the beds of the streams derived from them, and that in consequence the irrigable area of the oasis is diminishing.[b]

In the oasis, or oasis group, of El Oudiane 60 springs furnish the water with which the gardens are irrigated. They are generally smaller than those of Nefta and Tozer, and their flow is said to be perceptibly diminishing. Their waters are not united to form a large stream which is subsequently divided and subdivided by dams, as in the oases just described, but are for the most part conducted directly to the gardens. These, owing to the small width of the oasis and its situation at the very foot of the terrace, are nowhere far removed from the sources of supply.

At El Hamma there are 15 springs of considerable size, one of them having a temperature of 107.5° F. (42° C.). To this spring, which is much frequented by the natives for the sake of the hot baths it affords, the oasis owes its name, which means "the bath."

A sample of irrigating water was collected by the writer in the main stream of Tozer, above the first dam which divides it. This water, tested both at the moment of collection and two months later, when the analysis was made, gave neither an alkaline nor an acid reaction. Its electrical resistance at the time when the sample was taken was 117.3 ohms at 60° F. The chemical analysis, made in the laboratory of the Bureau of Soils, showed 209.2 parts of soluble matter per 100,000 of water. The composition of the soluble contents was as follows, in percentages of the total:

TABLE 8.—*Chemical composition of irrigation water, Tozer oasis.*

Components (ions).		Conventional combinations.	
Calcium	8.50	Calcium sulphate	28.87
Magnesium	4.54	Magnesium sulphate	17.36
Sodium	9.13	Potassium chlorid	23.47
Potassium	12.34	Magnesium chlorid	4.11
Sulphions	34.23	Sodium chlorid	16.68
Chlorions	24.33	Sodium bicarbonate	9.51
Carbonic acid	6.38		
	100.00		100.00

[a] At Biskra, in Algeria, 0.12 quart per palm per minute is found to give satisfactory results, the water being retained at the bases of the trees in holes that are dug for the purpose. (See Bul. 53, Bureau of Plant Industry, p. 47.)

[b] Doumet-Adanson (ibid.) noticed old date palms at Tozer that could no longer be irrigated, being no less than 40 feet above the present level of the springs.

It is evident from this analysis that the water afforded by the springs of Tozer is pure enough to be used with perfect safety in irrigating any crop grown there. As the springs of the other oases of the Jerid have a similar origin to those of Tozer, it is probable that the composition of their waters differs little from the foregoing.

IRRIGATION SYSTEM.

Irrigation at Tozer has been brought to a higher stage of development than elsewhere in the Jerid, and a description of the system in use at Tozer will serve for the other oases as well.[a] It is said to have been elaborated long ago by an Arab named Ben Chabet, and to have been religiously maintained, unchanged as he planned it, to this day.

FIG. 2.—Irrigation canal and diversion dam, Tozer oasis.

The details of its management are transmitted from father to son in a certain family. Having perfected the system at Tozer, Ben Chabet offered to do the same service for the inhabitants of Nefta, who were constantly in dispute over their water rights, but their jealousy of Tozer prevented their accepting his offer. French students of the Tozer system praise very highly the ingenuity and thoroughness with which it has been worked out.

The main stream which collects the waters of all the springs of Tozer is divided and subdivided by a series of dams made of palm logs (fig. 2) until the water reaches the ultimate divisions or seguias (ditches) which supply each individual garden. The log which

[a] For a detailed account of this system, see F. Masselot, "Les Dattiers des Oasis du Djérid," Bul. Dir. Agr. et Com. Tunis, 1901, pp. 137–142.

is laid across the canal to form the dam is divided into a series of long, shallow notches, separated by narrow ridges. The number of notches in each dam corresponds to the number of parts into which the stream is to be divided at that point. Thus, if three-fifths of the water is to be diverted into one of two branches and two-fifths into the other, five notches are cut, the water passing over three of them going to the first branch and the rest to the second. The notches being all of the same length and depth, the division is quite accurate. Divisions of the main stream down to the twenty-first part of the total flow are not transferable, belonging for all time to the same district of the oasis. Smaller fractions of the water, however, can be alienated, and there is much bartering of water rights among the different proprietors of gardens.

At all the principal diversion dams, guards are stationed day and night to prevent any tampering with the water, there being three guards at the first diversion and two at each of the other important ones. These guards are paid with a bunch of Fteemy dates from each garden that receives water passing over the dam they tend, those at the first diversion being entitled to a bunch from every garden in the oasis. The "amin,"[a] or expert, who supervises the entire system has also the right to select a bunch of Fteemy dates from every garden, his being the first choice after the "khammes," or tenant, of the garden.

The principal canals are kept up by assessment upon all the owners of gardens supplied by them. Smaller ditches (seguias) must be kept in order by the tenants of the gardens served by them, and it is also the duty of the khammes (tenant) to be on hand at the small dam which diverts water into his ditch when it is the turn of his garden to receive water, for there is a fixed hour for the irrigation of each garden.

The method of measuring time in connection with this irrigation system is an interesting one. A metal cup-like receptacle, called a "gadous," is filled with water and hung up in a convenient place by the dam. The bottom of the receptacle is perforated, and the hole is always of the exact size necessary to let all the water run out in just five minutes. The water that runs over a notch in the dam during the time required for the gadous to empty eleven times (hence, in fifty-five minutes) is sufficient to irrigate thoroughly a garden of 2.4 acres (1 hectare), the length of the notch being fixed and its depth corresponding to the velocity of the current.

[a] The "amins" (pronounced "ameens") are selected from among the older inhabitants of the community for their knowledge of agricultural matters. Their function is to act as arbiters in disputes concerning water rights, the relations between proprietors and tenants, the sale of agricultural products, etc.

The gardens are divided into small plots by means of banks of earth, to facilitate irrigation, as in the basin method used in the United States. The water from the ditch (seguia) is turned into the nearest plot through a breach made in its bank, the ditch being dammed at that point with a few spadefuls of earth. When the soil is sufficiently saturated, the farther bank is cut, allowing the water to pass on into the plot beyond; and so on, until the whole garden has been irrigated. In this way not only the date palms, but the other fruit trees and the small crops among them that occupy a portion of every garden, are irrigated simultaneously.

DRAINAGE SYSTEM.

Owing to the situation of the oases on the edge of the Shott Jerid and the great amount of water used in irrigation, its soils would be completely water-logged were it not for the excellent provision that has been made for drainage. Each garden is provided with open drainage ditches, or "khandaks," these being generally about 166 feet apart and about 5 feet deep. They are constructed at the expense of the proprietor of the garden, the work of keeping them open devolving upon his tenant. Several of these smaller drains unite to form a large ditch, which is kept up by an association of the proprietors whose gardens are served by it, each contributing in proportion to the size of his water right. Finally, at Tozer, all the drainage ditches empty into a main one called the "Khandak-el-Kebir," which runs along the southern side of the oasis and carries its drainage water to the Shott Jerid. In former times, when Tozer was frequently raided by the savage nomadic tribes of the desert, this large drainage ditch also served the inhabitants as a moat for the defense of the oasis. Not only is this excellent drainage system useful for ridding the oasis of surplus water, but it renders inestimable service in preventing the harmful accumulation of salts or "alkali." (See p. 36.)

SOILS OF THE JERID REGION.

TEXTURE.

As the soils of the Jerid region only were investigated, the discussion which follows relates only to that group of oases. All samples for analysis were collected at Tozer, but the composition of the soils of the other three oases is probably similar, except that those of Nefta apparently contain a higher percentage of sand. The date palm is said to grow most rapidly and vigorously in the soils that are richest in clay, although yielding a better quality of fruit in the sandier soils.

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The following table gives the results of mechanical analyses of the samples taken, as furnished by the Bureau of Soils. Descriptions of the localities where each sample was obtained will be found in Table 11, on page 37, under corresponding numbers.

TABLE 9.—*Mechanical analyses of soils of Tozer oasis.*

Number of sample	Depth of sample.	Character of soil.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
	Inches.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	0 to 36	Fine sandy clay, water at 36 inches depth.	0.3	4.0	4.0	17.6	23.1	13.0	38.6
2	0 to 36	Heavy, fine sandy loam, changes to blue clay near bottom of boring, water at 24 inches depth.	.9	6.3	6.5	22.1	36.1	7.8	20.5
3	0 to 24	Fine sandy clay, water at 12 inches depth.	.3	4.7	4.6	25.2	26.2	8.6	30.6
4	0 to 36	Fine sandy clay, water at 36 inches depth.	.3	3.2	3.7	19.4	25.8	11.2	36.4
5	0 to 36	Light, fine sandy clay	.5	4.5	5.3	19.7	34.3	6.9	28.7
6	36 to 72	Subsoil of No. 5, sandy clay, water at 60 inches depth.	1.4	5.2	5.4	21.1	32.5	5.3	29.9

It will be seen from the above analyses that the typical soil of Tozer oasis is a mixture of fine sand and clay, chiefly remarkable for its small percentage of silt. Soils of this type occur also in the Oued Rirh oases of Algeria. According to Dr. L. J. Briggs, they are seldom found (as soils) in the United States, although subsoils of similar composition are sometimes met with in the Atlantic Coastal Plain. In the field these soils do not impress one as being particularly heavy, notwithstanding the large amounts of clay they contain. The discrepancy is probably to be explained by the fact that they contain great quantities of lime in the form of calcium carbonate and of gypsum, calcium sulphate. (See Tables 11 and 12.) These salts have a tendency to cement the fine particles of clay into masses that imitate grains of sand and make the soil appear of coarser texture than it is found to be when examined in the laboratory. In the process of mechanical analysis much of the lime is dissolved and the fine clay particles fall apart. Furthermore, most of the relatively insoluble lime is probably classified as "clay" in computing the results of the mechanical analysis. A similar discrepancy between field observations and laboratory analysis was noted by Mr. Thomas H. Means and accounted for in this way in the case of soils from the Oued Rirh oases in Algeria.[a]

[a] See Bul. 80, Bureau of Plant Industry, pp. 41, 42 (1905). Many of the samples described in the table on page 42 of that bulletin show a mechanical composition very similar to the samples from Tozer.

In well-cultivated gardens the upper few inches of the soil contain a considerable amount of humus and are quite black in color, as would be expected from the fact that not only date palms and other fruit trees, but garden vegetables, forage crops, and cereals have been grown in the oases, probably without intermission, for many hundreds of years.

FERTILITY.

As to the composition of the soils of this oasis, so far as the important elements of plant food are concerned, the following table of a chemical analysis by acid digestion will furnish an indication:

TABLE 10.—*Plant food constituents of soils of Tozer oasis.*

	Per cent.
Nitrogen (total)	0.03
Lime (CaO)	13.08
Potash (K_2O)	1.10
Phosphoric acid (P_2O_5)	.14

The sample (No. 2 of Tables 9 and 11) was taken to a depth of 36 inches in a well-cultivated garden of young Deglet Noor palms, amid a thin, newly planted stand of alfalfa, and contained only a moderate amount of readily soluble "alkali" salts, as will be seen by reference to column 4 of Table 11.

If it be permissible to generalize upon the scanty data given above, it can be said that the soils of Tozer are decidedly low in nitrogen. When we consider that these soils are continually and lavishly irrigated with water that contains very little organic matter, that manure is scarce, and that leguminous crops occupy at no time more than a small fraction of the total area of the oasis, the poverty of the soil in nitrogen is not remarkable. If the analysis had been based only upon the surface 6 inches, a much better showing in this respect would doubtless have been made. Lime is present in much larger quantity than is usually considered necessary in the average cultivated soil. Potash, likewise, is present in far more than the usual proportions. Finally, the phosphoric-acid content is such as would generally be considered satisfactory.

According to the conventional standards the soils of Tozer would therefore be in all respects first-class, so far as plant-food constituents are concerned, were it not for their low nitrogen content. It would seem that to remedy this deficiency the growing of berseem (Egyptian clover) should be undertaken, as this crop ought to thrive in the Jerid region, with its mild winter climate and abundance of irrigating water.

ALKALI.

Where the gardens are well cared for and receive frequent irrigations, the soils contain very little readily soluble salts, and no trace of saline efflorescence is to be seen. But in neglected parts of the oasis, and especially in the low-lying lands situated near the Shott Jerid, the ground is often covered with a glistening white crust of salt, often to a depth of half an inch or more. Throughout the oasis one sees pieces of land that have been left for several years without irrigation, although surrounded on all sides by well-cared-for gardens. While the soil of the gardens only a few rods distant does not contain a large amount of readily soluble salts, the surface of the abandoned tract is usually covered with a white efflorescence, and bears a scattered vegetation of fleshy-stemmed "pickle weeds" or other salt-loving plants and an occasional small, stunted date palm. (Pl. II, fig. 1.)

Obviously all that is needed to rid the soil of such tracts of its excess of salts and to render it in all respects suitable for cultivation is the construction of drains, coupled with abundant irrigation. The soils are light enough and their slope is sufficient to render it an easy matter to wash out the salt in a short time. This the natives thoroughly appreciate. The writer saw several long-neglected gardens at Tozer that were in process of reclamation. In commencing operations the ground is worked over to a depth of 3 feet (Pl. II, fig. 2), and in case a heavy crust of salt has accumulated this is frequently scraped off and carted away. The latter operation is unnecessary, although doubtless helping to shorten the period of reclamation. Nowhere in the Jerid does there appear to be the least difficulty in reclaiming salt land if this method of flooding is followed. At Nefta, especially in the part of the oasis nearest the shott, new gardens of date palms are being established in land that is white with salt (Pl. VII, fig. 2). The natives agree that this can be removed very rapidly and completely if proper methods are used.

In the following table are presented the results of chemical analyses of soil samples taken in different parts of the oasis of Tozer, the first six numbers being identical with those in the table of mechanical analyses on page 34.

TABLE 11.—*Chemical composition of soils of Tozer oasis.*

No. of sample.	Description of locality where sample was taken.	Depth of sample.	Percentages of water-soluble components based on dry weight of soil.		Percentage of calcium carbonate based on dry weight of soil by acid digestion.
			Calculated from electrical resistance of saturated soil.	By chemical analysis of solution in 20 parts water to 1 part soil.	
		Inches.			
1	Open ground, surrounded by date gardens, much white saline efflorescence on surface; growth of salt-loving weeds.	0 to 36	2.90	6.58	14.29
2	In garden adjoining No. 1, among young, thrifty Deglet Noor palms planted the year before in a thin stand of alfalfa	0 to 36	.54	5.33	12.84
3	In land, recently broken up for reclamation, of a neglected garden where palms had suffered from lack of irrigation	0 to 24	.20	4.82	10.24
4	In land still uncleared and covered with a dense growth of weeds and grass, in same garden as No. 3	0 to 36	.30	5.37	16.32
5	In unirrigated land lying higher than surrounding gardens; heavy efflorescence; scattered, stunted palms; growth of salt-loving weeds	0 to 36	.58	3.99	13.73
6	Same boring as No. 5, lower depth	36 to 72	.96	5.78	11.95
7	In garden among young Deglet Noor palms and a good stand of alfalfa; water at 36 inches	0 to 36	.2		
8	In unirrigated land outside garden in which No. 7 was taken, amid a growth of salt-loving grass and rushes; water at 24 inches	0 to 36	.97		
9	Saline crust from neighborhood of main drainage ditch; very little vegetation	0 to 1		54.1	5.39

The following table gives the composition of the totals of water-soluble salts, of which the percentages, based on dry weight of soil, are given in column 5 of the preceding table:

TABLE 12.—*Composition of water-soluble salts in soils of Tozer oasis.*

Number of sample.	Constituents, by analysis.							
	Ca.	Mg.	Na.	K.	SO_4.	Cl.	HCO_3.	PO_4.
1	18.49	3.31	6.53	2.22	54.95	13.23	1.27	Tr.
2	25.19	1.50	.34	2.84	65.97	2.36	1.80	Tr.
3	21.19	.83	4.81	3.86	67.56	Tr.	1.75	Tr.
4	21.34	1.12	3.76	4.81	65.61	1.57	1.79	Tr.
5	24.71	2.10	1.00	1.65	63.23	4.90	2.41	Tr.
6	24.78	1.55	.62	3.18	64.83	3.38	1.66	Tr.
9	3.39	4.70	21.36	2.41	50.63	17.17	.34	Tr.

Number of sample.	Conventional combinations, calculated.								
	$CaSO_4$.	$MgSO_4$.	$MgCl_2$.	KCl.	K_2SO_4.	$KHCO_3$.	$NaHCO_3$.	NaCl.	Na_2SO_4.
1	62.82	13.29	2.49	4.22			1.73	15.45	
2	85.57	7.05	.30	4.46		1.31	1.31		
3	71.99	4.11			8.59		2.37		12.94
4	72.51	5.32			10.71		2.46	2.56	6.44
5	83.92	5.0[illegible]	4.31	3.15			3.31	.30	
6	84.20	6.81	.66	6.05			2.28		
9	11.52	23.27		4.59			.47	24.73	35.42

Upon examination of the data given in Table 11, a striking discrepancy is seen to exist between the percentages of water-soluble components to dry weight of soil, as stated in columns 4 and 5, respectively. By reference to Table 12, however, the explanation is found to be simple. In taking the electrical resistance of the sample, the soil was mixed with just a sufficient quantity of distilled water to bring it to the point of saturation, which in soils of this texture was found to be about 30 per cent of the dry weight of the soil; and the reading is taken as soon as the soil and water are thoroughly mixed. In making the chemical analyses, on the other hand, one part of soil is digested in 20 parts of water, and the mixture is allowed to stand twenty-four hours to bring it to an equilibrium before it is filtered.[a] By the second method the soil is in contact with from 60 to 100 times as much water as by the first method, and for nearly 288 times as long. Consequently a great amount of calcium sulphate goes into solution when the soil is prepared for chemical analysis that remains in the solid state and is hence unaccounted for in the samples as made up for a test of electrical resistance. By reference to column 2 of Table 12 it is seen that (except in sample 9) calcium sulphate amounts to from 60 to 85 per cent of the total water-soluble matter, of which only an insignificant fraction can be dissolved in the amount of water and with the limited time allowed for taking the electrical resistance.

It should be said in this connection that experiments have shown a saturated, pure solution of calcium sulphate to be harmless and even beneficial to plants, and that an excess of calcium sulphate in the presence of magnesium and sodium salts has an extraordinary influence in modifying the toxic action of the latter.[b] The calculations of water-soluble contents of the soil based upon the electrical resistance, although confessedly only rough approximations, are of some value as indicating the amount of the readily soluble and actually harmful saline contents of the soil. On the other hand, they do not include the gypsum or calcium sulphate that is present, and thus do not tell the whole story. If the latter were merely neutral, it could simply be deducted from the total salts as ascertained by chemical analysis; but as it plays an important part in counteracting the effect of the sodium and magnesium salts, its presence can not be ignored.

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[a] For a description of the methods used, see Cameron in Bul. 18, Bureau of Soils, U. S. Dept. of Agriculture, pp. 66 and 67. For a discussion at some length of the significance of the high gypsum content of these soils, see W. T. Swingle, Bul. 53, Bureau of Plant Industry, pp. 73 and 74.

[b] Compare Kearney and Cameron in Report No. 71, U. S. Dept. of Agriculture, p. 39.

Turning to Table 12, let us compare the different samples as to their chemical composition. We notice at once that sulphuric acid is the acid and calcium the base which largely predominate in all of them, excepting sample No. 9. The latter, consisting of the efflorescence that is brought out on the surface of the soil by the combined action of capillarity and evaporation, is necessarily deficient in the slightly soluble calcium salts.[a] In the crust, as well as in the soils, however, sulphuric acid is by far the most important constituent. We may therefore regard the "alkali" of Tozer oasis as of the sulphate type.[b]

Free carbonates were not detected by the phenolphthalein test, either in the field or in the laboratory, except in the crust (sample No. 9), in which a very faint alkaline reaction was observed upon testing the freshly collected sample. In all other cases the reaction was neutral, not only at the time the samples were collected, but four months afterwards when examined in the laboratory. "Black alkali," therefore, apparently does not exist in Tozer oasis. The high percentages of calcium carbonate obtained by acid digestion of the soils (see column 6 of Table 11) would suggest the possibility of its formation under certain conditions were it not for the relatively small amount of sodium and the great quantity of calcium and sulphuric acid present.

The percentages of potassium and of carbonic acid differ comparatively little in the different samples, while those of sodium and of hydrochloric acid show very considerable variation. The relatively small part played by hydrochloric acid is surprising, when we consider that in the adjacent Shott Jerid mines of table salt exist. The smooth crust of salt that covers the bottom of the shott has the appearance of containing a higher percentage of sodium chlorid than do the efflorescences upon the soils of the oases, the latter being of the fluffy, powdery aspect which the presence of a large amount of sulphates generally produces.

It is interesting to note the difference in composition between the efflorescence (sample No. 9) and the soil solutions (samples Nos. 1 to 6). In addition to the very small percentage of calcium in the crust, as compared with the soil samples, we remark in the crust a considerably higher percentage of magnesium, a very much higher percentage of sodium and of hydrochloric acid, and a much lower

[a] In discussing "alkali" soils of Utah, Gardner and Jensen (Field Operations of the Division of Soils for 1900, p. 231) remark: "Lime is always present in the soil alkali in appreciable amounts, whereas in the crusts it is usually absent."

[b] In the soils of the Oued Rirh oases, in Algeria, also, sulphates generally predominate over chlorids, although the converse is frequently true. (See Bul. 53, Bureau of Plant Industry, p. 96; and Bul. 80, Bureau of Plant Industry, p. 46.)

percentage of carbonic acid. In respect to potash and sulphuric acid the difference is not noteworthy.

It remains to consider the composition of the drainage water. A sample was taken from the "Khandak-el-Kebir," the main drainage ditch of the oasis of Tozer (see p. 33), at a point some distance beyond the last garden toward the shott. This sample, like that of the irrigation water described on page 30, after having been kept for two months in a rubber-stoppered bottle, remained perfectly sweet and good. Tested with phenolphthalein as soon as it was collected, the water showed a very faint pinkish opalescence, indicating a slight trace of free carbonates. An analysis of this sample in the laboratories of the Bureau of Soils showed the presence of 530.4 parts of salts per 100,000 of water, which is a little more than two and one-half times the amount found in the irrigating water (see p. 30). Water of this concentration could be safely used in irrigating many crops,[a] and considering the fact that the drains penetrate everywhere, and that the sample was collected at a season (February 5) when comparatively little irrigation is going on, its relatively small salt content indicates that the soils of the oasis generally are not highly saline.

TABLE 13.—*Chemical composition of drainage water, Tozer oasis.*

Percentages of different constituents.		Conventional combinations.	
Calcium	9.97	Calcium sulphate	33.86
Magnesium	5.30	Magnesium sulphate	16.54
Sodium	8.67	Potassium chlorid	16.70
Potassium	8.77	Magnesium chlorid	7.69
Sulphions	37.11	Sodium chlorid	14.80
Chlorions	22.64	Sodium bicarbonate	10.39
Carbonic acid	7.54		
	100.00		100.00

Comparing the percentage composition of the saline matters in the drainage water with that of the irrigation water, we find a remarkably close agreement. As compared with the soil samples (Nos. 1 to 6 in Table 12), the drainage water contains relatively much more magnesium, sodium, and potassium and very much less calcium. In respect to acid constituents there is relatively much less sulphuric acid and much more hydrochloric and carbonic acids. In comparison with the salt crust, of which a sample was taken near the spot where the water sample was collected (sample 9 in Table 12), the drainage water contains relatively much more calcium, potassium, and carbonic acid and considerably more hydrochloric acid. On the other hand, it is much poorer in sodium and is considerably poorer in sulphuric acid than is the crust.

[a] See T. H. Means, Circ. 10, Bureau of Soils; and Bul. 80, Bureau of Plant Industry, p. 38.

When we consider the great predominance of calcium sulphate and the absence of easily soluble carbonates ("black alkali") in the soils of Tozer oasis, it is apparent that the type of "alkali" occurring there is a relatively harmless one. In view of the relatively small percentages of readily soluble salts, as indicated by the electrical resistances of the soils of well-kept gardens, and taking into account the thorough drainage system of the oasis, the "alkali" problem can not be regarded as a very serious one in this region.

CULTURE OF THE DATE PALM.

As the gardens of the Jerid only were investigated in any detail, the following notes relate principally to that region, although most of the observations are doubtless equally applicable to the other oases of southern Tunis. Cultural methods could not be given the thorough investigation the subject warrants, the writer's time having been mainly taken up in studying the characters of the different varieties and in getting together the collection of offshoots for shipment to the United States. Yet it is thought that some of the information obtained will offer useful suggestions to future date growers in this country. The following discussion is based partly upon notes obligingly furnished by M. Minangoin, inspector of agriculture at Tunis, and upon the published paper of M. Masselot,[a] and partly upon data obtained by observation and by questioning the inhabitants. In regard to the latter source of information, it should be said that while the cultural methods used by the Arabs appear to have generally a common-sense foundation, the reasons which they give for their practices are often extremely childish. As a rule, they follow slavishly the precepts that have been handed down to them by wiser ancestors, without concerning themselves about why they do this or that. Yet, occasionally one meets an intelligent native who can give a rational explanation of most of his proceedings.

SIZE AND VALUE OF THE GARDENS.

The size of the date gardens varies greatly. The largest in the Jerid is said to be that of Dobech, at Nefta, in which there are 2,800 palms. The writer was told that the annual revenue from this garden is from $4,500 to $5,000. At Tozer the largest garden, that known as "Mahaleb," is said to yield the owner $3,400 a year. The garden of Tishta, at Nefta, is remarkable for the large number of varieties it contains. It was formerly the property of a caid, whose hobby it was to collect as many different sorts as possible. Practically all

[a] Les Dattiers des Oasis du Djérid. Bul. Dir. Agr. et Com., Tunis, 1901, pp. 114–161.

been engaged here, as in the Oued Rirh oases of Algeria, in establishing plantations of date palms.

According to official estimates there should be about 96 trees to the acre in the gardens of Tozer, but in reality they are much more densely crowded, only taxable palms, i. e., those in full bearing, being enumerated by the census takers. As many proprietors estimate the value of their gardens at the rate of $19 per tree in full bearing, an acre containing 96 date palms in good condition would be worth $1,824. But since the value of a palm depends largely upon the variety to which it belongs, and as most of the gardens contain many trees of inferior varieties mixed with the better sorts, it is probable that the figure mentioned is too high as an average for the whole region. On the other hand, an acre of Deglet Noor palms in full bearing would doubtless be worth even more; but there are very few gardens in the Tunis oases in which the Deglet Noor variety constitutes even one-half of the total number of trees. At Nefta, according to official estimates, the average number of trees per acre is 125, while in the neglected oasis of El Hamma it is only from 62 to 75.

Each garden is surrounded by a "tabia," or wall of mud, surmounted by a palisade of palm leaves, the whole being generally 5 or 6 feet high.

LABOR AND TENANTRY SYSTEM.

Labor is abundant and very cheap in that part of the world. The inhabitants of the oases, having devoted themselves for many centuries to the culture of the date palm, are thoroughly familiar with every detail of it, although the great majority of them carry on the necessary operations instinctively rather than intelligently. For the ordinary work of the gardens an abundance of labor is available; but for operations demanding especial skill, such as detaching suckers for planting, pollinating the flower clusters, and gathering the fruits of the best varieties, experts are required, and these are much less numerous.

At Nefta and at El Oudiane many of the owners manage their own gardens, while others employ a tenant, or "khammes." At Tozer the latter system is all but universal, and in consequence the gardens are often less well kept. The khammes is so-called from the fact that he is supposed to receive one-fifth of the product of the gardens, khammes being the Arabic word for "fifth." As a matter of fact, this manner of payment no longer obtains in the Jerid. Nowadays the khammes is entitled to one-eighth of the yield of trees of all varieties, except the Deglet Noor, and to one bunch of fruit from each ten trees of the latter kind. In addition, he is permitted to raise

vegetables, forage crops, and grain in the gardens (Pl. VII, fig. 2) and he is allowed as much as he wishes of these products for his own use, besides one-fourth of the proceeds of what is sold.

In return, the khammes is expected not only to carry on all the work of the garden—irrigation, cultivation, manuring, pollinating the female flower clusters, etc.—and to keep in repair the ditches for irrigation (seguias) and those for drainage (khandaks), as well as the walls (tabias), but, when he has any spare time, to do domestic service for the proprietor. During the season when the fruit is ripening and needs to be guarded night and day to prevent its being stolen the khammes and his sons often camp in the garden, inhabiting a small tent or even sleeping in the open. At other times the gardeners and their families live in the towns, going each morning afoot or on donkey back to their work. There are no permanent habitations among the gardens, as the towns, being situated on higher, dry land (Pl. VI, fig. 3), are considered healthier. Even under these circumstances, however, the population of the Jerid is ravaged in summer and early autumn by malaria. The population, as a whole, is anemic, feeble, and subject to various diseases, notwithstanding the fine winter climate.

PROPAGATION.

In Tunis, as elsewhere in the Sahara, the date palm is intentionally propagated only by means of the offshoots that spring from the base of the trunk (Pl. V), which, in well-cared-for gardens, are taken only from trees belonging to good varieties and known for the quality of their fruit. But in neglected gardens and in waste ground many seedlings ("el hachana") spring up fortuitously, and in this way doubtless the many varieties have arisen. Seedling palms are, of course, rarely true to type, although the writer was gravely assured by an intelligent Arab that to make them come true it is only necessary to transplant them two or three times, and that this method is sometimes resorted to when suckers are not procurable, in order to perpetuate very rare varieties!

Manuring and watering freely are said to stimulate suckering, and the construction of a "dokana," or circular mound of earth and clay[a] (Pl. V, fig. 2), around the base of the palm is a good way to obtain strong, well-rooted offshoots. If an offshoot starts from the trunk some distance above the surface of the soil it can be made to take root by cutting away the outer leaves and fastening a basket filled with earth around its base. Offshoots produced by palms growing in open places, unshaded by other trees, are considered to

[a] Illustrated also in Bul. 86, Bureau of Plant Industry, Pl. V, fig. 1.

the opinion that offshoots developed in unirrigated and salty land make more vigorous palms than those grown in well-tended, frequently irrigated gardens. It is possible, at least, that such offshoots are hardier at the start and are less likely to perish in the early stages of growth.

The offshoots are generally of sufficient size to transplant when two or three years old, but they must not be taken up until they are well rooted. The natives say they are of the best size for planting when about as large as a camel's head at the base, but while still without a well-formed trunk above ground. One offshoot is generally left attached to each palm when the others are removed, in order to replace it when it dies or becomes unproductive. When this in turn produces offshoots, one of these is retained, and so on. Hence it is not unusual to see trunks belonging to several generations all still attached to the same parent stock. (Pl. V, fig. 2.) It must be remembered that a date palm generally ceases to sucker after it is 10 to 15 years old.

FIG. 3.—Laborer holding a "messah," or short-handled hoe.

FIG. 4.—Date picker holding a "mengel," or straight-bladed sickle, used for cutting off the bunches of dates.

The price paid for offshoots in the Jerid depends upon the variety, Deglet Noor offshoots selling for from 57 to 75 cents apiece, while those of most other varieties cost only from 19 to 57 cents.

Considerable skill is required in detaching the offshoots from the parent stem. First, all but the innermost leaves are cut off near the base, and those that are left are often fastened together with a shred of palm leaf, to prevent their being broken during the operations. Next, a hole of some size is dug around the offshoot with a pick or with the "messah," a short-handled hoe. This tool (fig. 3 and Pl. II, fig. 2) is quite unlike the Egyptian "fass,"[b] having a much larger, shovel-like blade, with the handle so attached as to be nearly parallel with the blade instead of at right angles to it. At the same time all the roots that can be reached are cut off close to the base by means of a "mengel," a tool with the

[a] The belief among the natives is that an offshoot must receive plenty of moonlight in order to become a strong palm!

[b] Illustrated in Bul. 130, Office of Experiment Stations, U. S. Dept. of Agriculture, 1903, p. 39.

shank and blade made in one piece of wrought iron and fitted with a wooden handle. It somewhat resembles a sickle, but has a straight, heavy, saw-edged blade nearly at right angles to the shank (fig. 4). One man then grasps the offshoot and pulls down on it, while another, armed with a chisel or a pick, pries it loose at its point of junction with the parent tree. The remaining roots are now cut off, and the sucker is ready to be planted. The cost of thus removing a sucker is generally 6 cents.

If the offshoot is to be transported a considerable distance before it is planted, it must be protected from drying by a wrapping of the coarse fiber (leef) that invests the bases of the leaf stalks of the date palm (fig. 5) or of some similar material.

PREPARING THE LAND.

The methods used in preparing the soil, especially if it contains "alkali," are essentially the same whether the plantation is to be made in new land or in an old garden that has been neglected. First, the irrigation and drainage ditches are dug or are cleaned out. Next, the soil is worked thoroughly to a depth of 3 to 6 feet with the short-handled hoe, or messah, this operation being accomplished by digging a trench of the required depth at one side of the garden and then working across. All stones, masses of gypsum, etc., encountered are carefully removed. The whole garden is then flooded to wash out whatever salt has accumulated near the surface of the soil. When that is accomplished, in order to facilitate irrigation the garden is divided up into "lands" that vary greatly in size, but rarely exceed 120 square yards (1 are). A donkey load of manure, carefully freed from straw, is frequently worked into the soil of each "land." Often, during the next two or three years, only vegetables, especially turnips, cabbage, and carrots, are grown before date palms are planted. It costs 14¼ cents to dig 15 feet of drainage ditch of the ordinary depth (5 feet), and from 4¾ to 13 cents annually to keep the same length in repair. Breaking up the ground with a messah costs from 28½ to $1.25 per 20 square feet, according to the depth of the hoeing and the character of the land.

FIG. 5. Camel carrying date offshoots wrapped in palm fiber (leef) for transportation.

PLANTING.

Planting is done in the Jerid during the months of March to June. It is said that in well-drained soils it can be begun with safety as early as March 1, but in very wet land must be postponed until a month later. At Gabes the amins say that if offshoots are detached in March, after the sap has begun to flow freely in the palm, the chances of their growing are better than if taken earlier, although they can be removed with little risk as early as February 15.

In the newer gardens of the Jerid the palms are generally set in with some attempt at alignment (Pl. VII, fig. 2) at intervals of 15 to 30 feet each way, 30 feet being recognized as quite sufficient for obtaining the maximum yields.[a] In the older gardens, as pointed out above, the trees stand at very irregular intervals and are often much crowded (Pls. I. and IV, fig. 2). The holes made to receive the offshoots are usually 3⅓ feet in diameter and about 1½ feet deep in new land, while in replacing an old or diseased palm the hole is made 3 to 6 feet deep, probably in order that as much as possible of the old soil may be removed. The hole is then filled with well-washed sand, which is trodden down firmly around the base of the offshoot as soon as it is set in and again after the first irrigation.

A practice that is highly recommended, particularly in gardens where the water table is high, is that of placing stones in the bottom of the hole so as to support the base of the offshoot, thus insuring good drainage. This custom has fallen into disuse in the Jerid, but when old trees are dug up there it is said that stones are frequently found among their roots. The practice still prevails in the Mzab oases of Algeria.[b]

It frequently happens that the offshoot is more or less curved. To make it develop into a straight palm, it is recommended to plant it with the concave side facing southeast, "like a man saying his prayers," as the Arabs express it. The young palm, thus receiving more of the sun's rays on its concave than on its convex side, gradually becomes straight.[c]

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[a] There is a proverb current among the inhabitants of the Mzab oases in Algeria (quoted by Charlet, Les Palmiers du Mzab, Bul. Soc. Géogr. d'Alger, 1905) to the effect that "If one plants at 30 cubits, one has dates without trouble; if one plants at 20 cubits, one has them only by taking great pains; but if one plants at 10 cubits, it is labor wasted."

[b] Charlet, Les Palmiers du Mzab, Bul. Soc. Géogr. d'Alger, 1905.

[c] The same practice occurs in the Mzab oases, according to Charlet (Bul. Soc. Géogr. d'Alger, 1905). This author makes the interesting statement that suckers sometimes finally grow that have shown no sign of life for one and one-half to two years after being planted. The natives say that growth can sometimes be started in such a case by transplanting to another part of the garden. They believe that the offshoot had willfully refused to grow in its first station on account of the dislike it had taken to some neighboring palm.

The cost of planting a palm is about 2½ cents, but in already established gardens the work of replacing old or diseased palms is part of the regular duties of the khammes, or tenant, for which he receives no extra compensation.

The young palm is usually sheltered by a tentlike covering of date palm leaves (Pl. II, fig. 2), until it is strong enough to face without protection the summer sun and the cold winds of winter. The shelter is generally left in place for a year, i. e., until the spring after the planting. Where palms are planted on the edge of an oasis, and hence beyond the shelter of older trees, "tabias," or palisades, to break the force of the sand-bearing winds (see p. 14), are often erected at intervals of 30 to 50 feet in the young plantation. It is estimated in the Jerid that from 10 to 15 per cent of the suckers planted fail to grow.

IRRIGATING.

As soon as the offshoot is planted a shallow basin is made around its base, in order to hold the irrigating water. Care is taken to construct this so that the water can not come in contact with the terminal bud, or "heart," of the young palm. During the first forty days after planting, many of the natives consider it preferable to water palms by hand from a water jar, at the rate of 4 gallons for each palm daily, rather than by flooding. It costs about 20 cents to water 30 palms daily in this way. After forty days two waterings a week are generally sufficient. At Nefta the growers told the writer that the practice is to water palms, until they are one year old, every day in summer, every four days in spring, and every eight days in autumn. If irrigated by flooding, two irrigations a week are generally sufficient, at least after the first few weeks, and two a month in rainy seasons, e. g., in autumn.

For older palms irrigation by flooding small basins, each containing several palms, is the only method practiced. One irrigation a week is generally sufficient, although a marked increase in yield is said to be obtained by irrigating twice a week. But many proprietors of gardens at Tozer, having disposed of part of their water right, get water only once or twice a month. According to an estimate made by M. Minangoin, water is ordinarily put on the land to a depth of about 2½ inches, of which nearly 1 inch is almost immediately absorbed by the soil. M. Masselot, however, states that the "lands" are flooded to a depth of about 4 inches at each irrigation. The amount of water theoretically available for each palm in the oasis of Tozer is variously estimated at from 42 to 62½ gallons daily. (Compare p. 29.)

Irrigation is most urgently required during the hot, dry months of June, July, and August, when the fruit is developing, and again in

November and December, after the harvest, the trees being at that time particularly weak and in need of stimulation. Irrigation throughout the winter is regarded as an excellent practice, as it stores the soil with water and makes it possible to get along with a smaller amount when the hot weather first begins. Land that is left entirely without water during the winter is said to become so dry that the first irrigations in summer can only wet the soil to a slight depth and the trees suffer from lack of water at the very time they need it most. In winter, however, irrigations are given much less frequently than at other seasons. It is said to be customary in winter to flood the whole garden at once, rather than to turn the water into small basins one at a time. Nor is so large a quantity of water necessary at each application, as it is not thought well to let the water stand on the land for any considerable length of time in winter, and the evaporation is naturally much less than in summer. Judging by the height of the ground water in the gardens of Tozer in midwinter (February 5), it would appear that the soils of the oasis are always in a very wet condition. Compare column 3 in Table 9, page 34.

No water should be applied for two or three weeks after the pollination of the female flower clusters in spring, as irrigation at that season causes the newly set fruit to drop off. Nor is it advisable to irrigate in the autumn for three or four weeks preceding the harvest, as otherwise the ripening fruit falls or else becomes so juicy that it molds easily and can not be preserved. Many gardeners withhold water from their palms from about the 1st of October until the dates are gathered.[a]

It has been pointed out in discussing the character of the drainage water (see p. 40) that this is not too saline for irrigation purposes. As a matter of fact, some of the gardens at Tozer lying nearest the Shott Jerid, and hence in the lowest part of the oasis, are irrigated solely with water from the drains. It is true that the palms are less thrifty and the yields obtained are smaller than elsewhere, but this is at least partly attributable to the poorer quality of the soils in that quarter and to the fact that in summer, when water is most needed, the drains are frequently empty.

[a] Charlet (Bul. Soc. Géogr. d'Alger, 1905) mentions that the same rule in regard to spring and fall irrigation obtains in the Mzab oases, where the application of water ceases about September 15, to be resumed after the harvest is completed.

MANURING.[a]

The continual irrigation of the oases and the small extent to which leguminous crops are grown among the palms are probably responsible for the low nitrogen content of the soil, as shown by the analysis on page 35. As far as possible the natives seek to remedy this deficiency by manuring. Unfortunately, owing to the small number of domestic animals kept, the supply of stable manure is very limited and the use of chemical fertilizers is as yet unknown.

No manure is given to the young palms when first set out, although where garden vegetables are grown in new land that is being prepared for a date orchard, as shown on page 45, the suckers doubtless receive some benefit from the manure that had been applied to the vegetables during the two or three preceding years. When the palm is 3 years old and is beginning to sucker it is manured directly for the first time. A circular trench is dug around the tree, at least 3 feet from its base. This is filled with one part of manure to two parts of earth, thoroughly mixed together. Frequently only one-half of the trench is dug and filled the first year, the circle being completed the year following. Subsequently the palm is usually manured only every four years, although some gardeners prefer to give a smaller application every year.

In the case of older palms the manure is spread on the surface and then worked into the ground, being applied at the rate of one donkey load to each tract of 7 square yards. Strong soils, containing a high percentage of clay or of organic matter and gypsum, are manured less heavily than the light sandy soils. Where garden vegetables are grown among the palms and manured every year the palms themselves receive no separate application. The best time to manure date palms is considered in the Jerid to be from October to January.[b]

Only thoroughly rotted manure that is at least one year old can safely be used. The natives recognize it as one of the advantages of old manure that it contains fewer viable weed seeds. Grass and straw are carefully removed before the manure is applied. The inhabitants differ as to what kind of manure gives the most satisfac-

[a] For the practices in this regard in the Oued Souf, see Bul. 86, Bureau of Plant Industry, pp. 22–24.

[b] According to Charlet (Bul. Soc. Géogr. d'Alger, 1905), many of the inhabitants of the Mazb manure their palms every year, sometimes at the beginning of winter and sometimes in February when the sap begins to run. This author estimates 44 pounds of manure as the quantity needed annually by each palm. In the Oued Souf (Bul. 86, Bureau of Plant Industry, p. 23) October and March are considered the best months for applying manure.

tory results with the date palm, some advocating that of camels, others that of donkeys.[a] But the total supply is too limited to allow of much choice in this respect, and every source is drawn upon, even to the scrapings of chicken yards and the refuse from human habitations.

OTHER CULTURAL METHODS.

When the palm has reached the age of 2 years, the old leaves and leaf stalks are trimmed off for the first time, but not too close to the ground, as in that case no suckers will develop. On the other hand, if left on the trunk these parts decay and sometimes cause the central bud to rot. It is considered important to work the soil around the palms to a moderate depth in the second and again in the third year after planting. Thereafter the ground should be worked over as often as possible. All cultivation is laboriously done with the messah, or short-handled hoe (see Pl. II, fig. 2, and text fig. 3, p. 44).

It is considered advisable not to permit the development of the earliest fruit clusters (which sometimes appear when the tree is only 4 years old), as too early production diminishes the vigor of the palm. In regard to the choice of other fruit trees to be planted among the date palms, figs and olives, being relatively shallow rooting, are recommended in preference to apricots, the latter being deep-rooted trees that compete with the palms themselves.

POLLINATION AND MALE PALMS.

The operation of pollination, which was not witnessed by the writer, has been described from personal observation by Mr. W. T. Swingle.[b] It is said to take place in the Jerid usually from March 15 to April 15. Male palms are not distinguished there according to variety, but according to their time of flowering, whether early, intermediate, or late,[c] and also, it is said, according to whether they originate from seed or from suckers. As a rule, the male palms resemble each other much more closely than do the female palms belonging to different varieties. They are distinguished from female palms in general by more numerous leaves and leaflets (Pl. IV, fig. 2) and often by a stouter trunk. According to M. Minangoin, the leaf stalks of male palms are very stout and the foliage is fine and soft looking.

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[a] One owner of a garden assured the writer that camel manure is "too strong" to be used in irrigated land, although it can be applied with perfect safety under the conditions prevailing in the Oued Souf.

[b] Bul. 53, Bureau of Plant Industry, pp. 26–29.

[c] Five suckers of each type of male palm, 15 in all, were imported into the United States from the Jerid.

In the Jerid oases, males constitute a very small p total number of palms. One male is said to furnish for fecundating 500 to 600 females. In the most e of Tozer oasis the writer was shown an unusually lar which he was told served not only for all of the fi this garden, considerably more than 1,000, but for r dens as well. The flowers of male palms are said who wish to use them, without compensation to the ov are reputed to live longer than the females, but fi tall that it is difficult to gather the flower clusters. the fate of female palms that have ceased to bear, t being girdled in order to extract lagmi, or palm wi that sooner or later results in the death of the tree.

The writer saw, in February, a palm (illustrated i which had all the characters of a male, as the tenant which it grew declared it to be. Nevertheless, it small, seedless green dates, similar to the "sichi" fruits of the Fteemy variety (see p. 70). Although served by him, this is apparently a rather well-known

RIPENING.

The bunches of dates often become too heavy fo bear them. To prevent the breaking of the fruit st are therefore frequently "straddled" upon the nea shown in Plate III. This is an operation that requ skill, and, in the case of choice varieties, is usually expert.

Much rain during the first few weeks after poll jurious as irrigation at that season, causing the ne drop. On the rare occasions when rain falls durin May, June, and July—that is to say, after the fruit fore it begins to ripen—it does no harm. During tl when the dates are maturing, hot, dry winds from th are favorable, as they hasten the ripening process fruit from becoming wormy. On the other hand, a h season is disastrous. If it falls in August or Septen the fruit to drop before maturity; if a little later, t rot or to become moldy. When the dates have becon a light rain is rather beneficial than otherwise, as it s washes off the dust that has gathered on them. B

[a] J. W. Toumey (Bul. 29, Ariz. Exp. Sta., 1898) notes tl date palms at Phoenix, Ariz., and at La Paz, Mexico. (Géogr. d'Alger, 1905), mentions the existence of two fruiting Mzab oases.

causes the ripe fruit to sweat and, while not injuring its flavor, lessens its exportability. The relation between the late summer and autumn rainfall and the quality of the dates is brought out in Table 4, on page 25.

To illustrate the opinion of the inhabitants of the Jerid concerning the effect of rain in early autumn upon their principal crop, the following anecdote, current among them, is related by Masselot:[a]

Once upon a time, after several years of drought and at length of famine, the bey had ordered that public prayers for rain be said throughout the regency. The people of the Jerid, alone among his subjects, refused to obey the order of their sovereign. The latter, in anger, ordered the chief notables among the refractory inhabitants to come to Tunis to receive punishment, had them appear before him, and said to them: "How happens it that when I command public prayers in order to attract God's attention to us and bring us the blessed rain that will give wealth to our unhappy country, you alone should dare to disobey this order, given in the general interest?" "You have acted rightly," replied the chief men of the Jerid, "but so far as our country is concerned, rain would have been its ruin. Behold this soft and fragrant ball of honey. Add a little water to it and what does it become? A coarse, tasteless liquid. Such are our dates, which in order to produce their honey require many rays of the sun, but not a drop of rain." The bey was convinced, it is said, and permitted them to return to their homes.

It is said that Deglet Noor dates should not be gathered much before the end of October, as, no matter how perfect their condition seems to be, if harvested earlier they will discolor and become wormy within a few weeks. It was suggested by a date buyer at Tozer that by cutting about one-third way through the main stalk of the fruit cluster when the dates begin to mature, and thus shutting off part of the water that passes through the stalk, the fruits can be made to ripen earlier without injury to their keeping quality. The experiment is at least worth trying. It is said that Deglet Noor dates can also be ripened faster by removing the bunches when the dates begin to soften and hanging them up in dry rooms.

HARVESTING.

Different varieties of dates mature at different periods, the earliest in the Jerid commencing to ripen in August, or even toward the end of July, while the latest are not all ripe before December. Consequently the harvest goes on in this region during about five months. The gathering of the Deglet Noor dates is done with especial care, as they are the only kind that is exported in any quantity to Europe. The harvest of this variety begins in earnest toward the end of October (about October 25 in 1904) and often continues into the first days of January. Of course, all the fruit that will ripen has matured long before the latter date, but the skilled laborers re-

[a] Bul. Dir. Agr. et Com., Tunis, 1901, pp. 122, 123.

quired are not sufficiently numerous to gather all tl
as it is ready to harvest. Fortunately, this is one of
dates of which can be left on the palms without in
weeks after maturing, provided the autumn is a dry

The Deglet Noor crop is generally purchased on t
harvest is supervised by the buyer or his agent.
on small trees which can be reached from the groun
preferred by the more wealthy natives for their ov
being less liable to injury in the harvesting. Palms
however, are generally too tall to allow their fruit to
easily. The harvest from such trees is a rather com
giving employment to a large number of men. (Pl.

First there is the "getaa," whose work requires
Armed with a "mengel" (see fig. 4, p. 44) he clim
the palm, cuts away with a few deft strokes such of
as hang in his way, and then proceeds to sever the st
bunches. Along the trunk below him a sort of hu
meanwhile been formed, the number of men and bo
it depending of course upon the height of the tree.
eight men besides the getaa clinging to one tall De
Supporting themselves with one arm around the tru
the scaly bark with their bare feet, they hand down t
one to another as they are received from the getaa
product of the tree is safely on the ground. The tree
with wonderful celerity, to the accompaniment of
ripe fruits that become detached from the bunches.

The getaa receives from 38 to 57 cents per day for
Noor dates, while the "meddada," who pass the bu
trunk, are each paid 19 to 24 cents per day. Even
reach the ground they are handled by a little army c
each of whom has some small duty in connection w
Thus the "lagata" are occupied solely in picking
dates that fall while the bunches are being cut an
ground. Each of them is paid 12 to 15 cents a da
whose duty it is to carry the bunches to the central
product of the whole garden is collected, are entitled
cents each. The "batah," or men who guard the h
the belongings of the workmen, receive the sa
"jerrara" transport the dates from the garden to
and receive for each donkey load about 11 pounds of
dropped off the bunches. Then there is the "alleg,

[a] It is said that the owners of gardens are held to be acq
gation as good Mohammedans to devote a tithe of their in
they give employment during the date harvest to a sufficient
of the oasis.

animals for the "jerrara," and the "khartaf," who attaches cords to the bunches and brings them to the "alleg" and who also arranges the bunches upon beams in the storehouse where they are dried.

It is said that one getaa can keep employed seven meddada, twelve lagata, two adal, six jerrara, one alleg, and one khartaf. In one day a skilled getaa can harvest the dates from 60 to 90 palms, according to the height of the trees. With the above-mentioned number of assistants of all classes, he can harvest on an average 5,500 pounds of dates daily.

Deglet Noor dates that are to be exported to Europe are often packed for shipment in the gardens where they are grown. A large part of the crop is put up in wooden boxes holding 22 pounds each, which is the maximum weight that can be sent by parcels post in a single package. (See Pl. I, Frontispiece.) They are then transported by caravan to the railway terminus, which is about 35 miles from Tozer.

The fruits of a few of the best varieties other than the Deglet Noor are harvested with the same degree of care. In the case of certain rare and highly esteemed sorts, especially of the earlier ripening varieties, the fruits are even picked one by one from the bunches as they mature. These are dates that are reserved for the tables of the wealthiest class of natives. But in harvesting by far the greatest number of varieties, including the popular Fteemy date, which constitutes probably more than one-half the total crop of the Jerid, the bunches, as they are cut by the getaa, are merely dropped upon mats spread on the ground underneath the palm, instead of being passed from hand to hand by the "meddada." In harvesting Fteemy dates the men are paid in kind. For each day's work the getaa is entitled to a bunch, which he selects among the finest, to two bunches of medium value, and to 11 pounds of detached fruit.[a] The other laborers are paid with a proportionate share of dates. For harvesting "khalt," or dry dates, the daily wage of the getaa is eight measures of fruit, amounting to about 88 pounds.

PRESERVING.

The fruits of the different varieties differ greatly in their keeping quality. Some must be eaten fresh, remaining edible at most only a few weeks after ripening. Certain kinds, including some that keep very well when ripe, are nevertheless preferred by the natives when in the "besser" stage; that is, before they are perfectly soft and ripe. These have the peculiarity of losing their astringency before they be-

[a] According to Masselot (ibid., p. 124), the total value of this quantity of fruit would be about 95 cents (5 francs). If this be true, the getaa receives about twice as much for harvesting Fteemy as for harvesting Deglet Noor dates, which seems improbable.

come very soft. Some kinds, both of soft and of dry dates, can be preserved several years without spoiling, although dry dates are apt to become excessively hard when kept for a long time. Soft, sirupy dates of good keeping quality, such as the Rhars and the Lagoo, are preserved in earthenware jars or in skin bags. The finer sorts, such as the Deglet Noor, are often hung up in bunches in the houses of the natives, and are picked off or else served on the branch as wanted.

It is said that the fruits of some varieties can be preserved only by leaving them on the bunch until they are completely dry, when they can be detached. Others which are especially liable to become wormy should be dried in the sun, after first splitting them open and removing the seeds.

VARIETIES OF THE DATE PALM IN TUNIS.

While it is impossible to state exactly the number of well-defined varieties of the date palm occurring in Tunis, it is probably not far from 150. The Jerid oases are particularly rich in varieties, containing considerably more than 100 distinct kinds.[a] Some of these are extremely local. At Nefta several varieties were seen that apparently do not occur at Tozer, while in the Nefzaoua there are many kinds that are very rare or entirely wanting in the Jerid, and vice versa. Yet certain varieties (the Kenta and Areshty, for example) are widely distributed, being found not only in all the Tunis oases, but also in those of eastern Algeria. Each group of oases in Tunis has its characteristic varieties. Thus, in the Jerid the Fteemy is by far the most abundant sort, while in the Nefzaoua, Gabes, and Gafsa groups it is rare or absent. Varieties such as Doonga and Zekry, which are important and highly esteemed in the Nefzaoua, are hardly known in the Jerid, although the nearest oases of the two groups are only about 30 miles distant. The Boo Hath'm variety, one of the most abundant at Gabes and at Gafsa, is apparently wanting in the two other groups.

Nearly all the gardens contain a large number of varieties, mixed together in the greatest confusion. Only in the newer gardens of the Jerid do we find plantations of the Deglet Noor occupying areas of some size, to the exclusion of other kinds. One large garden at Tozer is remarkable for containing almost solely the Deglet Noor and Fteemy varieties, but this is a rare exception. The present tendency is to plant Deglet Noor offshoots as fast as they can be obtained, and

[a] Du Paty de Clam published (Bul. de Géogr. Hist. et Descr., No. 3, 1893) a list of 74 varieties found in the Jerid. Masselot (Bul. Dir. Agr. et Com. Tunis, pp. 146–161, 1901) enumerates 94 named varieties. The writer was able to obtain fruit of all but 23 of these, and examined fruits of 21 named varieties not included in Masselot's catalogue.

very young plantations on the edges of the oases of Tozer and Nefta (Pl. VII, fig. 2) often contain only Deglet Noor and Fteemy palms.

In this bulletin only varieties that exist in the Jerid and Nefzaoua oases are treated. However, most of the important Tunisian varieties are thus included, there being few at Gafsa and at Gabes which do not also occur in one or both of the other groups. Descriptions are given of all the varieties that are at all abundant in the Jerid and the Nefzaoua, as well as of all that could be found that are noteworthy for their quality. Yet there are probably three times as many named and well-defined varieties in the region as are described in this paper; and the writer examined, photographed, and obtained samples of the fruits of nearly twice as many. Many of these, however, are extremely rare, in some cases being probably confined to a single garden.

Suckers of all the varieties described, with the exception of the Chedakh, Deglet Hamidatoo, Deglet Hassen, Khalt Menakhry, and Selatny, were brought to the United States.[a] Eleven varieties, of which suckers were imported, could not be included in the "Key to the varieties," at the end of this bulletin, as either the fruits were not seen or else samples and photographs were not obtained. Their characters, so far as known, are described under the heading "Varieties imported but not included in the key," page 90.

The Arabic names of the varieties alone are in use. In all matters of nomenclature and orthography Mr. W. T. Swingle, who has given much consideration to this subject, was freely consulted. In the main the names as given by the writer are identical with those given by Masselot,[b] although the spelling has been altered to the extent necessary to render it phonetic for English-speaking readers. The names of the varieties described in this paper which do not occur in Masselot's list are spelled phonetically as pronounced for the writer by the natives. In some cases, where the name of a variety differs in different oasis groups, the pronunciation current in the Jerid oases is followed as the standard.

At the end of this report, in the descriptive key (p. 97), the fruit characters that appear to be most useful for the identification of the varieties are described in detail. In the present chapter, brief descriptions of the fruits as to size, shape, flavor, and keeping quality, and in many cases of the characters of the palms themselves, are given. Geographical distribution, abundance or rarity, productiveness, earliness of ripening, commercial importance, vigor, rapidity of growth, and alkali resistance are also discussed.

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[a] These five varieties are nevertheless described, the first because of its abundance, and the others because of their fine quality; and thus practically all the important varieties of the Jerid are treated in this paper.

[b] Bul. Dir. Agr. et Com. Tunis, pp. 146–161 (1901).

In classing the varieties as of first, second, or minor importance, such points as the size, flavor, earliness of ripening, and keeping quality of the fruit, the thickness of the flesh, and the proportionate size of the seed, as well as the rapidity of growth, hardiness, and productiveness of the trees have all been considered. Thus the Fteemy variety (Pl. X, fig. 3), although not ranking with the Deglet Noor (Pl. VIII, fig. 1) in respect to flavor and cleanness of skin, is yet a very attractive date and is remarkable for the ease with which it is propagated, its rapid growth, vigor, and productivity. Hence it has seemed advisable to place it in the first class, and the Kenta variety (Pl. X, fig. 2) has been inserted there for similar reasons. On the other hand, the Mokh Begry (Pl. X, fig. 4), although of delicious flavor and highly esteemed by the Arabs, is not as attractive as other kinds in the shape and size of its fruit, besides being a rather light bearer. Consequently it is ranked as of secondary importance.

It should be remembered that, in judging such characters as flavor, personal bias enters very largely into the equation. In regard to the fruits of several varieties, the writer's opinion did not at all agree with that of the inhabitants of the oases, nor has it always coincided with that of colleagues in the Department of Agriculture with whom he has compared notes in testing dates.

Another point that should be emphasized is the great likelihood that the varieties imported will undergo more or less change in their new environment, some improving and others deteriorating. It is by no means impossible that varieties which in Tunis appear to be second-rate or even of minor importance will take rank among the best when grown in the United States, and that some of the kinds that are classed in this paper as of first importance will not prove to be the best adapted to our conditions. At all events it will be extremely interesting to watch the behavior of the Tunisian varieties that have been introduced into the United States.

Among Tunis dates the Menakher variety (see also p. 60) must be given first rank, so far as the quality of the fruits is concerned. (See Pls. V and VIII, fig. 2.) These are fully equal to the Deglet Noor in flavor, cleanness of skin, and keeping quality, and are usually 1½ to 1⅔ times as large as the latter. The fruits appear to ripen earlier, and the trees are said to give considerably heavier yields than the Deglet Noor variety. Unfortunately Menakher palms are so extremely rare that only nine offshoots of this variety could be obtained for importation into the United States. Even rarer is the Selatny date (see fig. 52, p. 93), the fruits of which resemble and perhaps equal the Deglet Noor in flavor, and are as large as those of the Menakher. These two varieties are in fact nearly extinct. At the ordinary rate of propagation it would require a great many years to

Yet the excellent quality and the large size of these dates would undoubtedly make them marketable at high prices if they could be had. So far as Selatny is concerned, there seems to be little chance of obtaining offshoots, but the Menakher variety has been introduced in sufficient number to give a fair opportunity for establishing it in this country. It remains to devise some means of speedy propagation by means of smaller offshoots than are generally taken for planting. Perhaps the offshoots can be removed before they have formed roots and then can be nursed in greenhouses until well rooted. The variety is so promising that no pains should be spared in multiplying it as rapidly as possible.

As regards actual commercial importance, the Deglet Noor variety is easily first. (Pls. VI, fig. 1, and VIII, fig. 1.) No other kind that is at all common equals it in quality. Its exquisite flavor, handsome appearance, cleanness of skin, and admirable keeping quality give it a deserved preeminence among the dates that are extensively grown in North Africa, and have made it the only Algerian or Tunisian date that is largely exported to Europe and America. Yet it has some serious disadvantages, else it would be hardly worth while to experiment in this country with any other variety. The greatest of these is its late ripening, or, in other words, its very high requirement as to total heat, a requirement that can probably be met in but very few localities in the United States. Another drawback is the relatively small average yield of the palms. In both these regards the Menakher variety appears to surpass the Deglet Noor, while equaling the latter in the quality and greatly exceeding it in the size of the fruits.

The Boo Affar (Pl. IX, fig. 2) is hardly inferior to the Menakher in many of the qualities of a first-class date. Its large fruits have a very fine flavor and very thick flesh, abounding in sugar. It is one of the handsomest of dates, being especially noticeable for its splendid coloring. The large size and unusual, almost perfectly globular shape of the Tronja date (Pls. IV, fig. 1, and IX, fig. 1) will at once attract attention. These peculiarities are associated with great thickness of flesh and a very rich flavor. Unfortunately, not much is known as to the productiveness of the variety. The Boo Fagoos (fig. 10, p. 67) is also remarkable for the form of its fruit, which is somewhat fiddle-shaped and of fairly large size. It has a very rich, attractive flavor, and, like the Tronja, is held in high esteem by the natives of the region where it grows. All three of these varieties offer great possibilities as a fancy dessert fruit, commanding a high price in the market.

The Tafazween (fig. 11, p. 68) is the best of the rather long, slender dates examined by the writer. It is decidedly attractive, with its

bright bay color and transparent flesh, nor does its flavor belie its appearance. It seems to be an earlier ripening kind than the Deglet Noor, and might be expected to take its place in regions where the sum total of temperatures is not quite sufficient to ripen the latter.

Although decidedly inferior in flavor and probably in keeping quality to the Deglet Noor, the Fteemy (Pls. VII and X, fig. 3) is a fine variety. It is by far the most abundant kind grown in the Jerid oases and is surpassed by none in productiveness, rapidity of growth, vigor, and hardiness. The fruit is handsome and highly colored, the flesh soft and sirupy, and the flavor so rich and sweet that Fteemy dates can not be eaten in large quantity at any one time. In the writer's judgment this is a finer fruit than the Rhars, that is so extensively grown in Algeria, although it shares with the latter the disadvantage of being sticky when fresh and consequently difficult to handle as a dessert fruit. It is a late-ripening sort, little if at all earlier than the Deglet Noor, and hence should not be planted except in the warmest localities of the Southwestern States. It has, however, a decided advantage over the Deglet Noor variety in point of rapidity and vigor of growth and in productiveness, being said to yield heavily every year.

Areshty (fig. 13, p. 71) is a variety considerably resembling the Boo Affar in size and shape, but is less richly flavored and less brightly colored. In its rather firm flesh and wholesome, moderately sweet flavor it resembles dates of the dry class. Were it not for the great size of its fruits it would be somewhat doubtful whether this should be classed as a variety of primary importance, as the flavor, although attractive, is not to be compared with that of the Deglet Noor and hardly equals that of the Fteemy variety.

The Horra variety (Pl. X, fig. 1) is very highly spoken of by French settlers in the oases, and is exported in small quantity to Europe. While from a botanical point of view it belongs to the "dry date" class, in reality its flesh is thick and never becomes very dry or hard. It is easily the finest of its type. The flavor is delicious, yet not so rich as to fatigue the palate. When we consider, furthermore, the good size of the handsome fruit, its early ripening, and the hardiness of the palms, there seems ample justification for giving the Horra a very high rank among Tunisian varieties.

Ranking next after the Horra among the dates of the dry type is the Kenta variety (Pl. X, fig. 2). This has a medium-sized fruit, smaller than the Horra. Its flesh is thicker and more tender than in most of its class. It ripens early, preserves well, and is one of the most productive of all varieties. The flavor is very agreeable and wholesome, while not so rich as to be easily cloying. Kenta palms appear to be unusually hardy and resistant to alkali in the soil.

DESCRIPTIONS OF THE VARIETIES.

In the descriptions that follow, the page number placed after the name of each variety refers to the descriptive key at the end of the bulletin (pp. 97–106), where a more detailed account of the characters of the fruits will be found. It should be noted that with few exceptions all the varieties can readily be referred to one or the other of two principal types—the "dry dates" and the "soft dates." (See p. 96.) The first are characterized by having the skin of the ripe fruit mostly roughened with numerous hard, narrow, transverse, as well as longitudinal, wrinkles, while the flesh is usually thin and generally becomes quite hard and dry in fruit that is long preserved. Plate X, figure 1, illustrates a typical date of this class. The soft dates, on the other hand, have the skin of the ripe fruit loosened over a great part of the surface into a few large, soft blisters, and the flesh is usually thick and remains soft, or at least tender. Typical soft dates are illustrated in Plates VIII and IX, figure 2. Dates of the first type are only moderately sweet, and as they can be eaten in quantity without inconvenience they form a large part of the food of the Arabs. Some of them, like Horra and Kenta, have a delicious flavor, while others are insipid. The soft dates, on the other hand, are generally so rich and sweet as to be rather a dessert fruit than a staple article of food. To this category belong the highly prized Deglet Noor, the choice Menakher, the rich, sirupy Fteemy—in short, most of the finest varieties. While many of these can be kept for a long time in good condition, others are not preservable, but must be eaten fresh or, at most, a few weeks after they are gathered.

Under the first heading following—"Varieties of primary importance"—these are arranged as nearly as possible in the order of their value, as determined by the considerations mentioned above. Under the headings "Varieties of secondary importance" and "Varieties of minor importance" the varieties follow the order in which they are placed in the key. The "Varieties imported but not included in the key" and "Varieties included in the key but not imported" are arranged alphabetically.

VARIETIES OF PRIMARY IMPORTANCE.

SOFT DATES.

MENAKHER (p. 106).—Fruit of the soft-date type (Pl. VIII, fig. 2), 2 to 2¼ inches long, about one-half as wide, oblong, broad and rounded at both ends, keeping its shape well when preserved; brownish maroon when ripe; the flesh 2 to 2½ lines thick; the seed broad at both ends, about one-half as long as the fruit, one-half as wide as long, very rough. (Fig. 6.)

The leaves (Pl. V) are long and broad and rather stiff and heavy, crowded with very numerous long leaflets, and their stalks are armed almost throughout their length with long, stout spines. The fruit clusters are short and dense, their stalks bright yellow (not at all orange), rather short, stout, and only moderately curved, so that the bundles do not hang down below the leaves, as in the Deglet Noor, but are almost hidden by the foliage.

This superb variety produces fruit that is thought by many of the natives, and even by some of the few Europeans who have tasted it, to surpass the Deglet Noor. In the writer's judgment and that of several of his colleagues who have given much attention to the subject of dates, as well as in the opinion of the experts attached to two of the largest American firms that import fruits, it is at least equal in quality to the Deglet Noor, which it considerably resembles in flavor. In size Menakher dates are one and one-half to nearly two times as large as the Deglet Noor.[a] In color they are generally darker. The seed, though thick, is short in proportion to the length of the fruit, and it is very different in appearance from that of the Deglet Noor. The thick, translucent flesh, although soft and sirupy at the moment of ripening, becomes firm when preserved, just as does that of the Deglet Noor. At the same time, it does not become dry and hard after a few months, as in most of the dry dates. If preserved with any care, Menakher dates keep their shape admirably. Those that were examined and tasted by the writer after having been kept for three or four months in the houses of natives showed themselves to be in all respects equal to the Deglet Noor in keeping quality. As in that variety, the

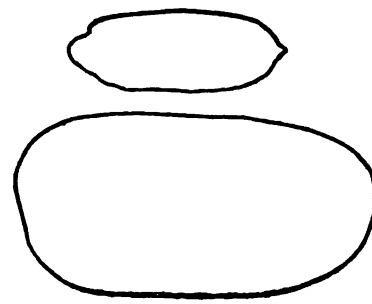

FIG. 6.—Outlines of Menakher seed and fruit. (Natural size.)

[a] Samples of Menakher and of Deglet Noor dates have recently (December 5, 1905) been received by the writer, through the kindness of Mr. Louis Grech, of Nefta, in southern Tunis. A comparison of the two shows that in volume (determined by the displacement of water) the former average 15 c. c. and the latter 9 c. c., the Menakher dates being, therefore, one and two-thirds times as large as those of the Deglet Noor variety. They are also about one and two-thirds times as heavy, Menakher fruits averaging 16.76 grams in weight, while Deglet Noor fruits average 10.44 grams. The percentage weight of the seed to that of the whole fruit (i. e., with the seed) is 10.4 in the case of the Menakher and 9.8 in the case of Deglet Noor. The importance of this character in distinguishing date varieties was first pointed out by Prof. J. W. Toumey. An exceptionally large Menakher fruit weighed 18.7 grams and the seed 1.7 grams, or only 9.1 per cent of the weight of the whole fruit.

skin does not become sticky, but remains dry and clean, which is a very desirable property in a dessert fruit.

An objectionable feature in Menakher dates is the strong development of the white, stringy core, or "rag," to borrow a term from the orange growers. This diminishes perceptibly, however, in thoroughly ripe fruit. The consensus of opinion among those who examined the two samples from Nefta mentioned in the footnote on page 61 is that in point of appearance, cleanness of skin, keeping quality, and delicacy of flavor the Menakher dates surpassed the Deglet Noor, while the latter are superior in the crisper texture of the flesh and the smaller development of stringy core. Menakher dates are generally reserved for the tables of the wealthier natives and for gifts to their friends. On the rare occasions when they are sold they are said to bring about one-third more than Deglet Noors.

The Menakher variety ripens its fruits in the latter part of October. It is said to yield little during the first few years after the offshoots are planted, but afterwards surpasses the Deglet Noor in yield, one palm producing sometimes 220 pounds of dates. Single clusters are said to be sometimes too heavy for a strong man to carry.

Menakher palms occur in the oases of Nefta, Tozer, and El Oudiane of the Jerid group, and are said also to occur in the Nefzaoua region, although the writer could not confirm the latter statement. They are everywhere, however, extremely rare, being found usually only in the largest and finest gardens, with rarely more than one individual in each garden. In the oasis of El Oudiane, where palms of this variety are said to be most frequent and to produce the finest fruit, there are probably not more than 12 or 15 trees, and most of these are old ones, no longer producing offshoots.

The natives give a curious account of the great rarity of this variety, which they hold in high esteem, and almost veneration. It appears that in former times the bey and other great dignitaries of the country were excessively fond of Menakher dates, and were in the habit of sending their agents to the Jerid at the time they ripen in order to procure them. As their fondness for these dates increased they began to appropriate the entire crop, leaving none for the unfortunate owners of the trees, and often forgetting to pay for what they took. Consequently the proprietors, in disgust, stopped planting offshoots of this variety and sometimes even went to the length of cutting down old palms.[a] Nowadays so few offshoots are left that there is some danger of the complete extinction of the variety. Even if every effort were made to reestablish it, it would require many years before Menakher dates could be produced in large quantity.

[a] The natives give the same explanation of the extreme rarity of the prized Selatny (see p. 93), the only Tunisian variety which might be considered first class of which the writer failed to procure offshoots.

Although the Arabs invariably relate the history given above in attempting to account for the passing of this choice variety, it is possible that there are other reasons for its rarity. Some of the gardeners who are familiar with it say that very careful nursing is required to make Menakher offshoots live and grow. On the other hand, Si Brahim Ben Ouedi, of Nefta, the owner of a fine young palm of this variety, says that while great care must be taken in detaching and planting Menakher offshoots, they are afterwards as easy to grow as those of other varieties.

After an exhaustive search of all the Jerid oases for Menakher offshoots only nine could be obtained for importation into the United States, of which six were so small that little hope was entertained of their living. Fortunately, they have been given every care in the cooperative date gardens of the Department of Agriculture and the Arizona and California experiment stations at Tempe, Ariz., and Mecca, Cal., and when seen by the writer in September, 1905, all of them seemed likely to grow. So even if this valuable date becomes extinct in the country of its origin, there is a fair prospect of its being continued in the United States. It should be stated that one of the finest of the offshoots was a gift to the Department of Agriculture on the part of Si Brahim Ben Ouedi, of Nefta, from the tree mentioned above and represented in Plate V, figure 1.

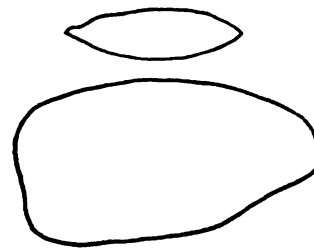

FIG. 7.—Outlines of Deglet Noor seed and fruit. (Natural size.)

DEGLET NOOR (p. 104).[a]—A soft date (Pls. I and VIII, fig. 1) 1½ to a little over 2 inches long, and about one-half as wide, ovate oblong in shape, generally widest at or near the middle, and blunt pointed at the apex, often narrowed also at the base, maroon colored when ripe, the flesh 2 to 3 lines thick, translucent, the seed a little more than one-half as long as the fruit, conspicuously pointed, and dark chestnut-brown in color. (Fig. 7.) The stalks and branches of the fruit clusters are bright yellow (not orange), the stalks long and slender, sharply curved near the base, so that the bunches hang down far below the crown of foliage. (Pl. VI, fig. 1.) The trunk is comparatively slender. The foliage is light and delicate looking, and the narrow leaves and leaflets are rather yellowish green. The spines are slender and weak.

This well-known variety is largely exported to Europe from Algeria and Tunis, and is practically the only North African date that is known in the United States. There can be no doubt that the

[a] Described in Bul. 53, Bureau of Plant Industry, pp. 33–36.

Deglet Noor presents a combination of characters—fine flavor, sweetness, attractive appearance, cleanliness, good keeping quality—that can be rivaled by no other variety that is widely grown in Algeria and Tunis. Only among very rare sorts, such as the Menakher (see p. 60), is there any possibility of its meeting a competitor. Even in the oases themselves it is the only kind that is found on the tables of Europeans or that is served by the more wealthy natives to their European guests. The general recognition of the superior quality and the commercial importance of the Deglet Noor is shown by the fact that the "kanoon" tax levied by the Tunisian government upon date palms in full bearing amounts to 1⅓ francs (25½ cents) for each Deglet Noor tree, and only two-thirds of a franc per tree for all other varieties.

The Deglet Noor ripens its fruit to perfection in the oases of the Jerid, and the government is attempting to establish it in the Nefzaoua region. Elsewhere in Tunis the climatic conditions are unfavorable to this variety, which is one of the latest sorts to ripen and requires a high sum total of mean temperatures above 64.4° F.[a] to bring it to perfect maturity. The maritime climate of Gabes is particularly ill adapted to the Deglet Noor, and the trials that have been made of it there have been unsuccessful.

First introduced into Tunis from the Oued Rirh, in Algeria, some 200 or 250 years ago, there are said to be now some 50,000 trees of this variety in the Jerid oases, in which case it constitutes 7 to 8 per cent of the total number of palms of all varieties.[b] The development of a very respectable export trade in Deglet Noor dates during the past ten or fifteen years[c] has stimulated the natives to plant trees of this variety, and the proportion of Deglet Noor to other palms will doubtless steadily increase from this time forward. As sufficient offshoots of this variety are not produced in their own gardens, the inhabitants of the Jerid have secured a modification of the Tunisian law against the importation of living plants,[d] thus allowing them to bring offshoots from the Oued Rirh oases in Algeria.

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[a] Estimated by W. T. Swingle (Bul. 53, Bureau of Plant Industry, p. 67) to aggregate 3,600° F.

[b] The total number of productive date palms in the Jerid in generally placed at from 600,000 to 700,000, although some authorities estimate as high as 1,000,000 trees.

[c] Estimated in 1893 to amount to 660,000 pounds, while in 1904 more than four times that quantity (2,860,000 pounds) is said to have been purchased for export—550,000 pounds by a single French firm. The annual exports of Deglet Noor dates from the ports of Tunis are said to have averaged in recent years 1,175,000 to 2,200,000 pounds, all of this quantity having been grown in the Jerid oases.

[d] Designed to prevent the introduction of phylloxera.

As to the quality of the Deglet Noor dates produced in the Jerid oases, the buyer for a well-known French importing house, who had operated during several previous years in the Oued Rirh but who last season (1904) made his purchases in the Tunis oases, was of the opinion that the latter region surpasses the Oued Rirh oases in the quality of its Deglet Noor dates. As compared with the fruits of this variety grown in the Oued Souf,[a] those of the Jerid are larger, softer, and of finer appearance, while the Deglets of the Souf are said to be superior in keeping quality.

The natives consider a sandy soil as decidedly more favorable to the quality of the Deglet Noor fruit than one containing much silt or clay.

Deglet Noor dates begin to ripen in quantity in the Jerid toward the end of October; Masselot gives October 25 as the usual date. The harvest of 1904 commenced about that date and continued throughout November, December, and the first days of January, 1905. The crop is generally purchased on the trees for about two-thirds of the price which the dates bring at wholesale at Marseille, and the buyer undertakes the gathering[b] and packing of the fruit. In 1904, when the crop was an unusually abundant one both in the Jerid and the Oued Rirh and the price correspondingly low, these dates sold on the trees for about $2.59 per 100 pounds, and brought at Marseille from $3.54 to $3.88. In 1903, when the crop was much smaller, Deglet Noor dates from the Jerid sold at Marseille for from $4.75 to $4.80 per 100 pounds. The season of 1904 was unusually favorable to the quality as well as the yield, less than 0.3 inch of rain having fallen at Tozer during the months of September and October together, and only 0.2 inch during November.

The Deglet Noor is slower in coming into full bearing than most other varieties, the palms generally not giving a good crop until they are ten years old, while the Fteemy variety begins to yield largely when only four or five years old. The fruit of very young trees is said to be usually inferior in quality. While some varieties bear well every year, a Deglet Noor palm produces largely only every second or third year, and the average crop is smaller than that of many less esteemed kinds. The average yield in the Jerid of Deglet Noor palms in full bearing is stated by one authority to be 132 pounds,[c] while

[a] See Bul. 86, Bureau of Plant Industry, p. 24.

[b] See p. 52 for an account of the methods of harvesting.

[c] In Algeria the average product of this variety is variously estimated to be from 88 to 132 pounds. (See Bul. 53, Bureau of Plant Industry, p. 35.) On account of its relatively low productiveness and its delicacy of constitution, the inhabitants of the Mzab oases are somewhat prejudiced against this variety, notwithstanding the undeniable excellence of its fruit. But, being largely

for the Fteemy and Kenta varieties 200 and 300 pounds, respectively, are not considered extraordinary yields.

Opinions differ in the Jerid as to the degree of resistance of this variety to large amounts of salts in the soil. The proprietor of one garden at Tozer, in a part of the oasis where there is much saline efflorescence, regarded the Deglet Noor as the most susceptible of all varieties to the effect of "alkali," while at El Hamma experts in date culture told the writer that, if freely irrigated, this variety shows a high degree of resistance.

Boo Affar (p. 101).—A soft date (Pl. IX, fig. 2), about 2 inches long and from a little more than one-half to three-fifths as wide, conspicuously wider above than below the middle but narrowed to the blunt apex, bright purplish maroon when ripe, the flesh 3 to 3½ lines thick, tender yet firm, the seed a little more than one-half as long as the fruit, cinnamon brown. (Fig. 8.) The stalks and branches of the fruit clusters are deep orange. The foliage is said to be heavy and the leaves wide and very green.

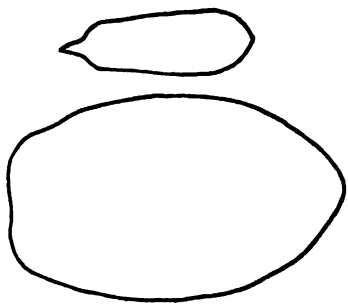

Fig. 8.—Outlines of Boo Affar seed and fruit. (Natural size.)

This variety occurs in the gardens of El Hamma oasis (Jerid) and in the Nefzaoua, but is nowhere common. The fruit is remarkable not only for its large size, thick flesh, and delicious flavor, but for its beautiful coloring, its tints rivaling those of scarlet oak leaves in the autumn. The fruit ripens rather late (in November, according to Masselot). It resembles that of the Areshty variety (see p. 70), but is much more highly colored. It is said to be better flavored than the Areshty when thoroughly ripe, and in the writer's opinion this is true. On the other hand, the natives prefer the fruit of Areshty to those of Boo Affar when only partly ripe. The flesh is tender, yet rather firm, and is very sweet and full of sugar. The skin, even of the ripe fruit, is fairly clean and dry. Of this variety 8 offshoots were imported.

Tronja (p. 99).—(Also spelled Troundja.) A soft date (Pl. IX, fig. 1), perfectly round, or nearly so, 1½ to nearly 2 inches in greatest diameter, maroon to prune purple when ripe, the flesh 4 to 5 lines thick, very sugary, yet firm; the seed very thick, six-tenths to seven-tenths as long as the fruit and about three-fifths as long as wide,

engaged in other business, they are not so dependent for a livelihood upon the product of their date palms as are the natives of other Saharan oases, else they would probably attach greater importance to the commercial superiority of the Deglet Noor. (See Charlet, in Bul. Soc. Géogr. d'Alger, 1905.)

much furrowed. The foliage (Pl. IV, fig. 1) is dense, the leaves wide, crowded with leaflets, and drooping gracefully at the ends.

This is a rare variety, apparently confined to Tunis, occurring sparingly in the Jerid and the Nefzaoua. The fruit, which ripens in October, is remarkable for its large size, the thickness of its flesh, and its globular shape. The short, very thick seed is also characteristic. (Fig. 9.)

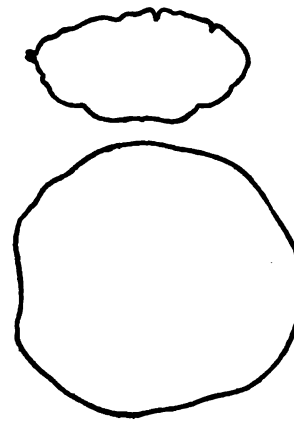

FIG. 9.—Outlines of Tronja seed and fruit. (Natural size.)

This date is highly esteemed by the natives. The flesh is very firm and even somewhat tough, extremely sweet, and very rich flavored, the flavor suggesting that of the Fteemy. Tronja dates can not be eaten in large quantity, as their richness soon cloys, but as a dessert fruit they are very promising. They ripen in October. Of this variety 8 offshoots were imported.

BOO FAGOOS (p. 101).—The name (in French orthography, Bou Fagous, or Feggouss) signifies "father of the cucumber." A soft date, 1⅜ to 1⅞ inches long, considerably more than one-half as wide, constricted near the middle and widest toward the apex, maroon to prune purple when ripe, the flesh 2½ lines thick, the seed from a little more than one-half to five-eighths as long as the fruit, rather slender. (Fig. 10.) The orange-colored stalks of the fruit clusters are sharply curved and so short that the rather small bunches hardly extend beyond the leafstalks. The foliage of this, as of several other of the finest varieties, is of a light and delicate aspect, due in this case to the relatively few leaves and the narrowness of the leaflets. The leaves themselves are large and wide. As in the Deglet Noor, they curve downward very noticeably. In color they are an unusually rich green. The spines of the leafstalks are few and weak. The offshoots remain small while attached to the parent tree, and the Arabs advise that greater care be taken to keep them moist after removal and before planting than is necessary with most other varieties.

FIG. 10.—Outlines of Boo Fagoos seed and fruit. (Natural size.)

The variety is rather common, but nowhere abundant, in the oases of the Jerid, to which it appears to be confined in Tunis, although said to occur also in the Mzab oases of Algeria. It is in high repute among the natives, being exported to all parts of Tunis and Al-

geria. The large fruit is remarkable for its unusual shape, somewhat like that of some varieties of gherkins, to which it doubtless owes its Arabic name. The flesh is thick and rather firm, yet tender. It is very sweet and has a very distinctive and highly attractive flavor. It ripens late in October. Of Boo Fagoos offshoots 16 were imported.

TAFAZWEEN (p. 101).—(Name spelled by French writers "Tafazaouine.") A soft date, 2 to 2¼ inches long, about two-fifths as wide, oblong, tapering slightly from base to apex, bright bay colored when ripe, the skin conspicuously marked with short linear scars, the flesh 1½ to 2 lines thick, the slender seed about three-fifths as long as the fruit. (Fig. 11.)

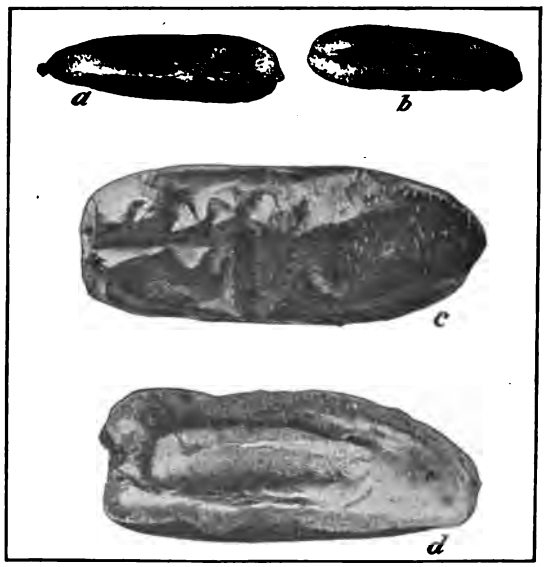

FIG. 11. Tafazween seeds and fruits. (Natural size.)

This variety is common in the Oued Souf, in Algeria, where it is considered one of the best dates of the region.[a] It is also found in the Mzab and Oued Rirh oases of Algeria. In the Jerid, where the name is pronounced "Tafazweent," it is extremely rare. The handsome fruit is easily recognized by its long, narrow shape, bright bay color, and curiously marked skin. It is said to ripen in October. The flesh is soft and translucent, like that of the Deglet Noor. It is very sweet and of excellent flavor, in this respect somewhat resembling Lagoo, but superior. Twenty-one offshoots of this promising variety were imported, of which only one was obtained in Tunis.

FTEEMY (p. 106).—(Name spelled by French authorities "Ftimi.") A soft date (Pl. X, fig. 3), 1⅔ to 2 inches long, about one-half as wide, oblong, slightly narrowed at both ends, dark purplish maroon when ripe, the surface shining, the flesh soft and sirupy, about 2 lines thick, the seed a little more than one-half as long as the fruit, slender. (Fig. 12.)

[a] See Bul. 86, Bureau of Plant Industry, p. 26.

The foliage of this variety (Pl. VII) is luxuriar
eus leaves are long, wide, and crowded with long, l
color they are decidedly bluish, owing to the pre
white bloom. When this is rubbed off, a rich, deep
appears. The spines are stout and green. The de
stalks of the fruit clusters are shorter, much stout
bent than in the Deglet Noor, so that the bunches c
below the crown of foliage, as in that variety. T
selves are shorter and more crowded with fruit.

This is by far the most abundant variety in the
prising probably at least one-third of all the da
region. The best fruit of this variety is said to b
oasis of Kriz (El Oudiane). In the Nefzaoua it
and in the oases near the coast it is of relatively
In the oases of eastern Algeria, although geogr
the Jerid and in such close communication with
this variety seems to be little known, although at Ourlana, in the Oued Rirh, it is said to occur under the name of "Bou Aroussa" (father of the bride). After the Deglet Noor, Fteemy is the variety most generally esteemed among the natives of the Jerid. Its great importance is shown by the fact that it is apparently the only variety of which the fruits are differently designated, according to whether they are in the bunch (halig) or detached (mantoor). It is la
other parts of Tunis and Algeria and even, it i
(probably to Italy). It is one of the kinds that is
by the nomadic Arabs who barter the grain they r
region for the dates of the Jerid.

FIG. 12.—C
and fr

Although inferior in flavor to the Deglet No
unquestionably an excellent variety, greatly exc
Noor in vigor, rapid growth,[a] early productiveness
The oblong fruit when ripe is of a fine reddish-p
contrasts strikingly with the deep orange branch
It is very rich in flavor, extremely sweet, and so
to melt in the mouth when fresh. It can not

[a] Mr. Bernard G. Johnson, who is stationed at the co
of the Bureau of Plant Industry and the California c
Mecca, Cal., reported in October, 1905, that among the
planted there in May of the same year, those of the Fteen
ing signs of growth in larger proportion than those of an

quantity, however, without cloying. A further disadvantage is that owing to the excess of sirup it contains, it becomes very sticky, and is therefore less satisfactory as a dessert fruit than the Deglet Noor. It is said to be easily preserved, and the Fteemy was enumerated at Kebili among the seven best-keeping sorts. Fteemy dates sold at Tozer in 1904 for about $1 per hundred pounds on the tree, which was about two-fifths of the price then being paid for Deglet Noor dates. The offshoots are cheaper than those of the Deglet Noor, 48 cents being the average price of a good offshoot.

The offshoots of this variety are frequently allowed to grow up around the parent stem, so that at length it is often hard to distinguish the original trunk. This is never permitted in the case of the Deglet Noor, the offshoots of that variety being always removed for planting while still quite small.

The habit of blossoming a second time, generally in July, is more characteristic of this than of any other Tunisian variety. The second-crop dates, being unpollinated, are seedless and remain small and green. In the autumn it is not uncommon to see large clusters of them overtopping the bunches of highly colored ripe dates. They remain upon the trees throughout the winter, and are said to become soft and edible in May.

The Fteemy variety is considered one of the most productive, giving a good crop every year. Trees bearing 15 to 20 well-filled clusters are frequently seen, and 200 pounds is by no means an unusual yield. The trees begin to bear a considerable amount of fruit when only five years old, so that this variety comes into bearing about twice as rapidly as the Deglet Noor.

Fteemy is a late-ripening variety, its fruit beginning to mature in quantity at the same time as the Deglet Noor (about October 20). As the dates can be left on the trees a long time after they are ripe without deterioration, unless much rain falls, the harvest of this variety is generally postponed until after that of the Deglet Noor. Fteemy dates are generally the last to be gathered, often remaining on the palms until the end of January.

In respect to ability to withstand "alkali" in the soil, the proprietor of a garden in the saline part of the oasis of Tozer told the writer that he considers this the most resistant variety, more so even than Kenteeshy. At Nefta the amins and other agricultural experts ranked it among the four most alkali-resistant varieties of the oasis. At El Hamma also it is regarded as one of the three or four most resistant kinds, provided it is abundantly irrigated. Of this variety 25 offshoots were imported.

Areshty (p. 101).—(Name spelled Arichti by French writers.) A soft date, $1\frac{2}{3}$ to $2\frac{1}{2}$ inches long, one-half to two-thirds as wide, slightly

larger above than below the middle, broad and rounded at the apex, light bay or hazel brown when ripe, the flesh 2½ to 3 lines thick, firm but tender, the seed about one-half as long as the fruit, rather thick, irregularly roughened. (Fig. 13.) The stalks and branches of the fruit clusters are pale orange. The foliage of this variety is rather light, and the leaves droop somewhat as in Deglet Noor palms. The Arabs say that the foliage of the Areshty is greener than that of the Deglet Noor. The leaflets are long, narrow, and rather sparse. The spines on the leafstalks are comparatively few, slender, and weak. The trunk is stout.

Frequent in the oases of the Jerid, the Nefzaoua, and Gabes, but nowhere abundant in Tunis. At Gabes the fruits are smaller and duller colored than in the Jerid, and are said not to preserve well. It occurs also in Algeria, at Biskra, and in the Oued Rirh. This is one of the largest dates grown in Tunis. The fruit is generally egg-shaped. It ripens about the middle of October, but is considered by the natives to be at its best before it is perfectly mature, although to an American palate it would doubtless be preferable when ripe. The flavor of the thoroughly ripe fruit is agreeable, although not very remarkable. While not as rich and sweet as the Boo Affar (see p. 66), it is wholesome, nut-like, and not easily cloying. The flesh becomes quite firm and the ripe fruit keeps its shape well when preserved. Thirteen Areshty offshoots were imported.

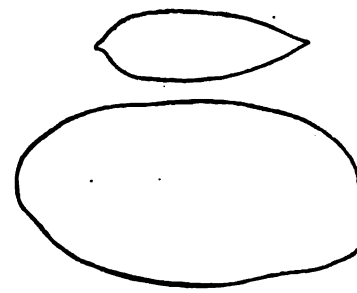

FIG. 13.—Outlines of Areshty seed and fruit. (Natural size.)

DRY DATES.

HORRA (p. 98).—The name is also spelled Hourra, Harra, and Herra, and means "pure" or "noble." A dry date (Pl. X, fig. 1), about 2 inches long, about one-half as wide, ovate, narrowed from the base to the rounded apex, rather dull purplish maroon when ripe, the flesh 2 to 2½ lines thick, with its white central zone much thicker than the dark outer portion, the seed usually about one-half as long as the fruit. (Fig. 14.) The stalks and branches of the fruit clusters are orange yellow. The leaves are large, with very numerous slender leaflets.

This variety, which also occurs in Algeria—at Biskra and in the Oued Rirh—is frequent in the Jerid and abundant in the Nefzaoua, where, the Deglet Noor not being grown, it is generally esteemed as the finest variety. At Gabes there are a few trees, but the variety

does not thrive well so near the sea. The fruit is the largest and finest produced by any variety of the dry date class. This, indeed, can be regarded as a connecting link between the dry dates and some of the firm-fleshed type of soft dates (Khalt Horraowia, Khalt Mooashem, etc.). Horra dates ripen in September and October. The flesh becomes quite solid in the ripe fruit, but is never extremely hard and dry. It has the characteristic nutty flavor of the dry dates, but is much richer than most of them. It is at its best only when perfectly mature. Europeans who are acquainted with this date praise it highly. Du Paty de Clam[a] pronounces it a "rival of the Deglet [Noor]." The commandant of the French garrison at Kebili likes it better than the Deglet Noor, and gives it the preference over all other varieties for planting in his garden. Not only is it highly esteemed by the natives, but it is said to be exported to Europe and even to France. The caid of Kebili ranks it among the seven best-keeping varieties of the Nefzaoua. It is a medium early sort, ripening in the latter part of October. The palms have not a very vigorous look, yet they appear to be resistant to alkali in the soil and to thrive with less irrigation than such varieties as Deglet Noor and Fteemy. Forty-eight offshoots of this variety were imported. Nearly all of these were obtained in the Nefzaoua, as in the Jerid offshoots are scarce and the natives are reluctant to part with them.

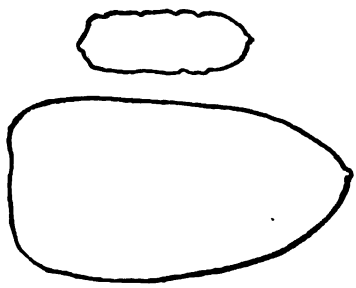

FIG. 14.—Outlines of Horra seed and fruit. (Natural size.)

KENTA (p. 97).—A date of the dry type (Pl. X, fig. 2), 1⅓ to 1⅔ inches long, about one-half as wide, narrowed from the middle or above it to the broad apex, dull bay colored when ripe, much of the skin loosened in large blisters in the ripe fruit, the flesh 1½ to 2 lines thick, the seed somewhat more than one-half as long as the fruit, rounded at both ends, light brown. (Fig. 15.) The leaves of this variety are rather broad, with numerous long, narrow leaflets. The long leafstalks are spiny only near the base. The light orange stalks of the fruit clusters are stout and horizontal or ascending, and so short that with the bunches they do not equal the leafstalks. The clusters themselves are short, thick, and densely crowded with fruit.

This is one of the most highly esteemed and most widely grown of the dry dates found in Tunis, and is said also to occur in Algeria. While abundant in the Jerid, it is relatively much more important

[a] Etude sur le Djérid, Bul. Géogr. Hist. et Descr., No. 3 (1893). Separate, issued in 1894, p. 12.

in the Nefzaoua. One-fourth of the palms in the oasis of Kebili are said to be of this variety, and the French commandant there has selected it, together with Horra (see p. 71), for planting in his garden. It is also very important at Gabes, where it is ranked among the six best kinds of the region. The fruit is of medium size and, as indicated in the key (p. 97), is remarkable among the dry dates for the manner in which the skin becomes loosened into large blisters, which is usually a peculiarity of the soft dates rather than of the dry dates. The flesh is rather thin and becomes quite firm, although not very dry, in the perfectly ripe fruit. The surface is clean and dry, even when the fruit is quite ripe. It is not sirupy, although pleasantly sweet, and can be eaten in quantity without cloying. The flavor is very agreeable, wholesome, and of the nutty quality characteristic of most dry dates. Dates of this type, if extensively grown in this country, might become an important element in the diet of those who prefer vegetable to animal food.[a] Fruit of this variety is said to sell on the trees at $1.12 to $1.20 per hundred pounds, a little less than one-half the selling price of Deglet Noor dates.

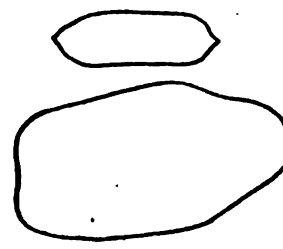

FIG. 15.—Outlines of Kenta seed and fruit. (Natural size.)

The Kenta date is one of the best in keeping quality of the dry dates, retaining its shape perfectly and never becoming extremely hard, as do most of that class. At Gabes it is preserved in earthenware jars, and is said by the amins (agricultural experts) to be one of the two best keeping sorts of the region. One of the amins, wishing to emphasize its importance as a staple article of food, likened it to wheat or barley and the soft dates to confectionery. The caid of Kebili cited it among the seven best-keeping varieties. It is an important article of commerce between the inhabitants of the oases and the natives of other parts of Tunis and Algeria, and is said even to be exported from the Nefzaoua to Europe (probably to Italy).

Kenta is a comparatively early ripening variety, maturing in the Jerid about the middle of October and perhaps earlier. Its fruits, like those of others of its type (e. g., Angoo and Remta), are said to be less liable than the soft dates to be spoiled if rain falls upon them when in the ripening stage. At Gabes it is regarded as one of the two most productive varieties. It is said to give an abundant crop every year. In the Jerid many trees are pointed out as yielding 330 pounds of fruit. M. Minangoin mentions a tree at El Oudiane that is said to produce 770 pounds, and also trees at Kebili at least 200 years old that still yield 265 pounds of fruit annually.

[a] As suggested by Mr. O. F. Cook. See Bul. 53, Bureau of Plant Industry, p. 31.

In the Jerid, Kenta is said to be the most salt-resistant variety in high-lying, well-drained land. At Gabes, on the other hand, it is cited as the only variety that is not salt resistant; but this may be because most of the saline land of the oases is low and badly drained.

Forty-three offshoots of this variety were imported, the great majority of which were obtained in the Nefzaoua oases.

VARIETIES OF SECONDARY IMPORTANCE.

DRY DATES.

ANGOO (p. 97).—Fruit barely 1 inch long, about seven-tenths as wide, sometimes broadest below, sometimes above the middle, bright bay colored when ripe, much of the skin becoming loosened in large blisters, the flesh a little more than 1 line thick, becoming firm and dry, the white central portion thicker than the dark-colored outer zone, the seed about two-thirds as long as the fruit, about one-half as wide as long, light (drab) brown. (Fig. 16.) The stalks of the fruit clusters are lemon yellow (not orange). The branches of the clusters are very densely crowded with the small fruits, which hang on persistently after ripening instead of becoming easily detached.

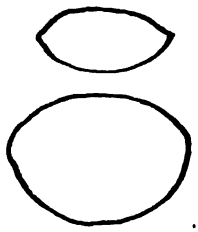

FIG. 16.—Outlines of Angoo seed and fruit. (Natural size.)

This, the smallest fruited of the Tunisian varieties, is found apparently only in the Jerid, and is best known as El Hamma. It appears to be nowhere common. Despite its diminutive size and thin flesh, this little date is one of the most attractive of the dry type. Because of its moderately sweet, nutty, wholesome flavor it can be eaten in large quantity without cloying, and should be a healthful food. Like Kenta (see p. 72), it is exceptional among the dry dates, because its skin becomes loosened into blisters over much of the surface of the fruit. The fruits are said to be little injured by autumn rains. They ripen in midautumn, keep well, and are much sought by the nomads of other parts of Tunis and Algeria. Of this variety ten offshoots were imported.

THABY (p. 98).—The name, which means "golden," is also written "Dzhabi," and is sometimes pronounced as if spelled Derby.[a] Fruit 1⅔ inches or slightly longer, about one-half as wide, oblong, often slightly constricted a little above the base, somewhat pointed at apex, bright reddish brown when ripe; the flesh 1 to 1½ lines thick, rather tough, the dark-colored outer zone apparently much thicker

[a] A variety called El Darbia, described as having a "green, dry fruit of medium size," occurs in Algeria.

than the white inner portion; seed about three-fifths as long as the fruit, rather slender. (Fig. 17.) The stalks and branches of the fruit clusters are rich orange colored.

This variety appears to be confined to the Jerid, and to be by no means common there. It is one of the handsomest of the dry dates, and one of the most attractive when preserved, keeping perfectly its shape and its beautiful warm, reddish brown color. Unlike most of the dry dates, in this variety the comparatively soft and dark part of the flesh is thicker than the firm, white core. It has an agreeable, wholesome flavor, and can be eaten in quantity without cloying It matures in October. Of the Thaby variety, fifteen offshoots were imported.

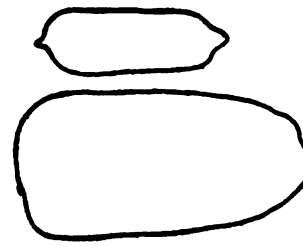

FIG. 17.—Outlines of Thaby seed and fruit. (Natural size.)

LEMSY (p. 99). Fruit $1\frac{1}{2}$ to $1\frac{3}{4}$ inches long, about one-half as wide, elliptical in outline, not conspicuously narrowed to the apex, often slightly curved, dull purplish maroon when ripe; the flesh 1 to 2 lines thick, becoming very firm and dry; the seed about two-thirds as long as the fruit, generally one-third as wide as long. (Fig. 18.) The branches of the fruit clusters are orange colored.

This variety is said to be known in the Nefzaoua as Haloba Hamra. It is common at Gabes and in the Nefzaoua, but is apparently wanting in the Jerid. It is a small, thin-fleshed, dry date, sometimes preserved, but usually eaten fresh and even before it is perfectly ripe, as the flesh soon becomes dry and hard. It is deliciously sweet and has a fine flavor, tasting somewhat like a chestnut. At Gabes, where it is regarded as a great delicacy, it is said to mature at the end of August, at the same time as Ammary (see p. 87). Of Lemsy two offshoots were imported.

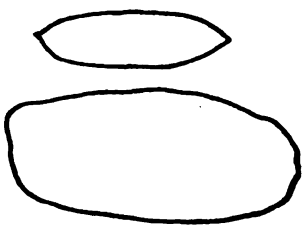

FIG. 18.—Outlines of Lemsy seed and fruit. (Natural size.)

HALOOA BAYDA (p. 99).—Also spelled "Halouaia," which designates the palm, "Haloba" referring to the fruit itself. The name means "white sweetmeat." Fruit $1\frac{1}{3}$ to $1\frac{1}{2}$ inches long, about one-half wide, elliptical in outline, not conspicuously narrowed at the apex, widest near the middle, dull purplish bay when ripe; the flesh 1 to $1\frac{1}{2}$ lines thick, becoming very firm and dry; the seed about seven-tenths as long as the fruit and one-third to two-fifths as wide as long. (Fig. 19.) The branches of the fruit clusters are pale orange.

Nefzaoua. The Haloua of the Algerian oases appears to be distinct (see p. 99). It is much like the Lemsy (see p. 75), but the fruit is even smaller. It ripens rather early (October 10, according to Masselot), and is generally eaten fresh, becoming hard and dry when preserved. Because of their simple, wholesome flavor and not excessive sweetness, the writer found it possible to eat dates such as Lemsy and Haloua Bayda much more freely than the rich, sirupy kinds. Offshoots of this variety to the number of 24, mostly obtained in the Nefzaoua, were imported.

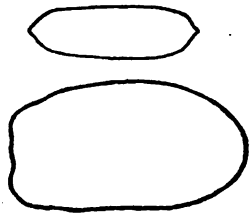

FIG. 19.—Outlines of Haloua Bayda seed and fruit. (Natural size.)

SOFT DATES.

MOKH BEGRY (p. 100).—French orthography, Moukh Begri. The name signifies "the brain of an ox." Fruit (Pl. X, fig. 4) $1\frac{1}{3}$ to $1\frac{1}{2}$ inches long, about three-fourths as wide, broadest at the base and narrowed thence to the broad rounded apex, flattened on the sides, bright bay colored when ripe; the flesh very soft, about $1\frac{1}{2}$ lines thick, rather dark colored, translucent; the seed light brown, one-half to two-thirds as long as the fruit, about twice as long as wide, rounded at both ends. (Fig. 20.) The stalks and branches of the fruit clusters are light orange.

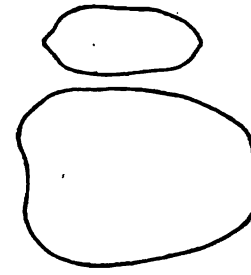

FIG. 20.—Outlines of Mokh Begry seed and fruit. (Natural size.)

This is an extremely rare and much esteemed variety, apparently occuring only in the Jerid oases. The trees are said not to bear heavily. The dates are rather small and have an unusual shape. The translucent flesh is very soft, but the fruit is said to preserve well. It is very sweet and of delicious flavor, resembling and perhaps equaling the Deglet Noor. The fruits ripen in the latter part of October. After a thorough search only two offshoots could be procured for importation.

BAYDH HAMMAM (p. 100).—The name means "pigeon egg." Fruit $1\frac{2}{3}$ to $1\frac{3}{4}$ inches long, three-eights to five-eighths as wide, egg-shaped, broadest near the middle, rather conspicuously blunt pointed at apex, not keeping its shape well, dark chestnut brown with a tinge of maroon when ripe; the flesh very soft and dark colored, about 2 lines thick; the seed one-half to five-eighths as long as the fruit, one-third to two-fifths as wide as long, dark brown. (Fig. 21.) The stalks and branches of the fruit clusters are orange colored. The

foliage is of a rather delicate aspect and the leaves numerous, the leaflets long, narrow, and rather sparse.

This is a handsome dark-brown date, with very soft dark-colored flesh. It is always eaten fresh, not being conservable. It is exceedingly sweet. The flavor of the perfectly ripe fruit is agreeable and very characteristic, resembling that of Tozer Zaid Safra (see p. 85). To the writer's taste, however, it is far less attractive than that of the Deglet Noor type or even of the dry dates, and it very soon cloys. The natives esteem it highly, as is shown by the fact that in harvesting the Baydh Hammam the clusters are carefully passed from hand to hand down the trunk, instead of being dropped to the ground by the man who cuts them. The Baydh Hammam is common in the Jerid, and is said to occur also in the Nefzaoua, as well as in Algeria (Biskra and Oued Rirh). It ripens rather late, hardly before November. Of this variety 20 offshoots were imported, all from the Jerid.

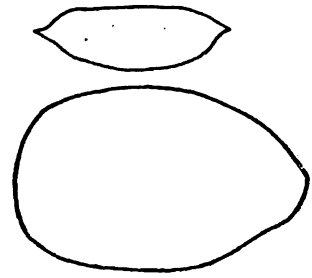

FIG. 21.—Outlines of Baydh Hammam seed and fruit. (Natural size.)

KSEBA (p. 100).—(Kessebi is probably another spelling of the same name.) Fruit about 1½ inches long, two-thirds as wide, ovate or oblong ovate, widest below the middle, purplish maroon or bay when ripe; the flesh 2 to 2½ lines thick, firm yet tender; the seed very nearly two-thirds as long as the fruit, two-fifths as wide as long, russet brown. (Fig. 22.) The branches of the fruit clusters are deep orange. The foliage is characterized by having few spines, and these are slender and weak.

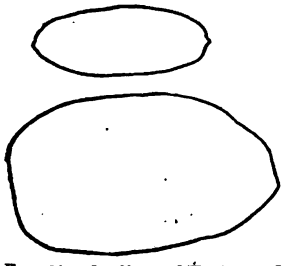

FIG. 22.—Outlines of Kseba seed and fruit. (Natural size.)

This variety is rare in the Jerid, but in the Nefzaoua, at Gabes, and at Gafsa it is one of the most important sorts. A date of the same name, described as a soft date, and possibly identical, occurs in the Oued Rirh oases of Algeria. The fruit, which preserves well, is very sweet and well flavored, in the latter respect being intermediate between Horra and Lagoo (see pp. 71 and 80). The Kseba variety, which ripens easily at Gafsa (see p. 20), may be found valuable for regions where the temperatures are not sufficiently high to mature the Deglet Noor and other choice sorts. Its fruits ripen in October. Offshoots to the number of 15 were imported.

DOONGA (p. 101).—Sometimes spelled "Denanga."[a] Fruit a little more than 1½ inches long, six-tenths to seven-tenths as wide, egg-

[a] The "Dengui" variety found at Gabes is a different date.

shaped, broadest near the base, dull dark purplish maroon when ripe; the flesh 1½ to 2 lines thick, the firm white central portion nearly as thick as the soft, dark outer zone; seed small and thick, only about one-half as long as the fruit and about one-half as wide as long, narrowed at both ends. (Fig. 23.) The stalks and branches of the fruit clusters are light orange.

This variety, which is one of the most highly esteemed and frequently planted in the Nefzaoua, does not appear to be found in the Jerid. It is a dark-colored, rather small date, with moderately soft, dark-colored flesh, and with a clean, dry skin. It is very sweet and of a fine flavor, suggesting that of the Deglet Noor. The number of Doonga offshoots imported was 10, all from the Nefzaoua.

Besser Haloo (p. 101).—Also spelled "Bisra Haloua." The name means a sweetmeat (haloo) that is eaten just before it is thoroughly ripe (besser). Fruit 1⅓ to 1½ inches long, about two-thirds as wide, broadest at or above the middle, rounded at the apex, keeping its shape well when ripe, bright bay colored; the flesh 2 lines thick, comparatively dry when the fruit is ripe, light brown; the seed two-thirds to three-fourths as long as the fruit, generally two-fifths as wide as long, with more or less conspicuous wing-like ridges on the sides. (Fig. 24.) The leaves are short and rather stiff, with comparatively short stalks and wide leaflets. The spreading or ascending stalks of the fruit clusters are so short that the small bunches are nearly hidden by the foliage.

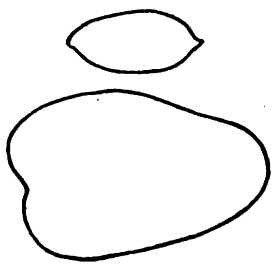

Fig. 23.—Outlines of Doonga seed and fruit. (Natural size.)

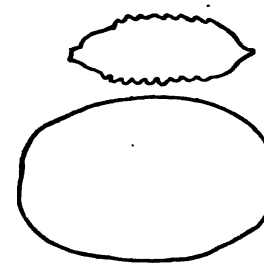

Fig. 24.—Outlines of Besser Haloo seed and fruit. (Natural size.)

This is a common and highly esteemed variety in the Jerid, and is said to be found also in the Nefzaoua, as well as at Biskra and in the Oued Rirh, in Algeria. It is one of the kinds that is most sought by the nomads of the interior, who come to the oases in the autumn to exchange their grain for dates. It is a small, light-colored date, with thick, comparatively firm flesh. It is very sweet and has an agreeable flavor, somewhat intermediate between that of Lagoo (p. 80) and that of Horra (p. 71). The natives seem to prefer it when not perfectly ripe. It matures early in October. According to information obtained by M. Minangoin, it yields a good crop every year and is one of the six most productive varieties of the Jerid. At Nefta the amins (see p. 32) rank it among the four most salt-resistant varieties

of the oasis. Of this variety 18 offshoots were importe
Jerid.

Okht Fteemy (p. 102).—The French orthography is
The name means "sister of Fteemy," this variet
sembling Fteemy in its trunk and foliage characters, a
fruits. Fruit 2 to 2⅛ inches long, about two-fifths as
straight, somewhat pointed at the apex, deep purplish
ripe, the surface shining; the flesh 2½ to 3 lines thick,
slender, about one-half as long as the fruit, less tha
wide as long, dark brown. (Fig. 25.) The stalks an
the fruit clusters are rich orange.
The numerous leaves are long and
broad, crowded with long leaflets.
The many fruit clusters are short-
stalked and almost hidden by the
foliage.

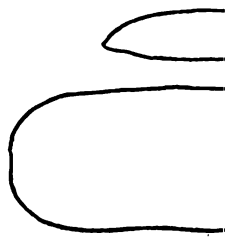

Fig. 25.—Outlines of Okh
fruit. (Natu

This variety appears to be con-
fined to the Jerid, being especially
abundant at Nefta, where it is pre-
ferred to Fteemy, while at Tozer
the latter is better liked. The very handsome fruit
more slender than that of Fteemy (p. 68), and is ofte
ored, but is otherwise very similar. In regard to fla
could detect no di
though very soft a
fruits preserve well,
being enumerated by
among the seven best
The fruits are said
most in demand b
from other parts of
who obtain their su
in the Jerid, and
4 measures (about
wheat for 9 measures (about 5½ pecks) of dates of this

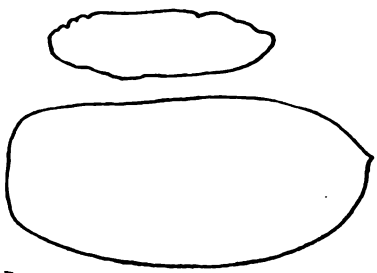

Fig. 26.—Outlines of Rhars seed and fruit.
(Natural size.)

Okht Fteemy palms give a good crop every year an
ductive, this being among the six best-yielding varieti
according to M. Minangoin. A tree at Nefta, by no
tionally productive, which had 15 well-furnished cl
was estimated by the tenant of the garden in which i
at least 220 pounds of fruit. These dates are not ge
fore November. The amins of Nefta place this among
alkali-resistant varieties of the oasis. Offshoots to th
were imported.

and is exported throughout Tunis and Algeria. Of this variety 23 offshoots were imported.

ZEKRY (p. 103).—Also spelled "Zechri." Fruit 1½ to nearly 1⅔ inches long, about one-half as wide, inversely egg-shaped, keeping its shape fairly well when preserved, bay to maroon when ripe; the flesh about 1½ lines thick, moderately soft; the seed between one-half and two-thirds as long as the fruit, about two-fifths as wide as long. (Fig. 28.) The stalks and branches of the fruit clusters are orange colored.

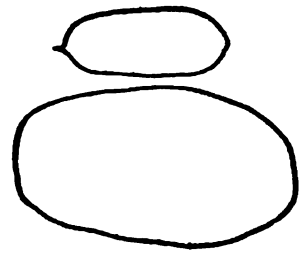

FIG. 28.—Outlines of Zekry seed and fruit. (Natural size.)

This variety, infrequent in the Jerid, is common in the Nefzaoua, where it is in high repute. When perfectly ripe the flesh, although rather thin, is soft and very sweet. The flavor is characteristic, suggesting both chestnuts and persimmons. The palms are said to yield heavily. Of this interesting variety 11 offshoots were imported, all from the Nefzaoua.

KHALT MOOASHEM (p. 104).—The name means "tattooed Khalt."[a] Fruit 1⅔ to nearly 2 inches long; about one-half as wide, egg-shaped, narrowed from about the middle to the rounded apex, keeping its shape perfectly when preserved, dark prune purple when ripe, the skin mostly adhering very closely to the flesh, conspicuously marked with transverse and longitudinal scars (hence the name); the flesh about 2 lines thick, firm yet tender; the seed about one-half as long as the fruit, nearly one-half as wide as long, broadest near the middle, light brown, rough. (Fig. 29.) The branches of the fruit clusters are bright orange.

FIG. 29.—Outlines of Khalt Mooashem seed and fruit. (Natural size.)

A rare variety of the Jerid. The excellent fruit is characterized by its dark prune color, curiously scarred skin, copious flesh, and very sweet, highly attractive flavor. It apparently keeps perfectly. Thirteen offshoots were imported.

KHALT DEGLAOWIA (p. 104).—The name signifies "Khalt resembling a Deglet (Noor)." Fruit 1⅔ to 1¾ inches long, about one-half as wide, egg-shaped, narrowed from about the middle to the rounded apex, keeping its shape well when preserved, dark maroon purple when ripe, much of the skin loosened into soft blisters, the flesh

[a] Although the word "khalt" is generally defined as meaning a dry date, most of the "khalts" of the Jerid oases which have received special names are soft dates and often of excellent quality.

about 2 lines thick, firm yet tender; the seed about two-fifths as long as the fruit, about one-third as wide as long, cinnamon brown. (Fig. 30.) The stalks and branches of the fruit clusters are light yellow (not orange).

This variety occurs apparently only at Nefta, and is not common there. The fruit is rather small, with fairly thick, firm flesh. The fine flavor suggests that of the Deglet Noor, which it resembles also in the shape of the fruit and the maize-yellow color of the branches of the clusters. Of this rare variety only two offshoots could be procured.

KHALT HORRAOWIA (p. 105).—The name means "Khalt resembling Horra." Fruit 1⅞ to over 2 inches long, narrowed from near the base to the somewhat pointed apex, keeping its shape well when preserved, dark maroon purple when ripe; the flesh 2 to 3 lines thick, firm yet tender, very sugary; the seed about one-half as long as the fruit, about one-third as wide as long. (Fig. 31.) The branches

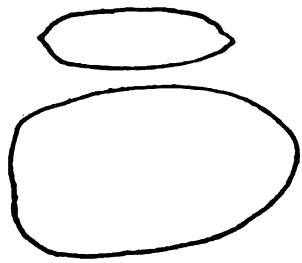

FIG. 30.—Outlines of Khalt Deglaowia seed and fruit. (Natural size.)

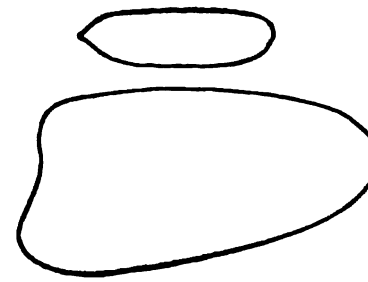

FIG. 31.—Outlines of Khalt Horraowia seed and fruit. (Natural size.)

of the fruit clusters are orange colored. The crown of foliage is well developed, the leaves large and the leaflets long and numerous.

A fine variety of the Jerid, by no means common. The large, handsome fruit somewhat resembles that of Horra (see p. 71), both in appearance and flavor. The flesh is copious, firm yet tender, and contains a great deal of sugar. Six offshoots were obtained.

VARIETIES OF MINOR IMPORTANCE.

DRY DATES.

BAYJOO (p. 97).—French orthography, Badjou. Fruit 1¼ inches long, about two-thirds as wide, egg-shaped, purplish maroon or bay colored when ripe; the flesh 1½ lines thick; the seed nearly two-thirds as long as the fruit, one-half as wide as long, light brown. (Fig. 32.) The stalks and branches of the fruit clusters are pale orange colored. The leaves are numerous, short but with long stalks and rather stiff, the leaflets long and broad but rather sparse. The small, dense bunches of fruit hang down on long curved stalks.

Abundant in the Jerid, and occurs also in the Nefzaoua. It is one of the varieties most widely exported to other parts of Tunis and Algeria. Flavor nutty, agreeable, but not very characteristic, typical of the dry date class. Matures in October (the 20th, according to Masselot). Number of offshoots imported, 7, all from the Jerid.

REMTA (p. 98).—Also spelled Remtsa (probably a misprint). Fruit 1½ to 1⅔ inches long, about one-half as wide, oblong, somewhat pointed (bluntly) at the apex, generally distinctly constricted a little above the base, dark maroon colored when ripe; the flesh about 1 line thick, rather tough; the seed one-half to two-thirds as long as the fruit, a little less than one-half as wide as long. (Fig. 33.) The stalks and branches of the fruit clusters are bright orange.

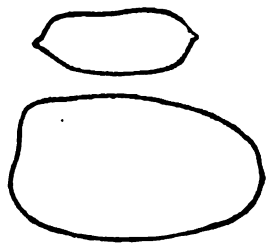

FIG. 32.—Outlines of Bayjoo seed and fruit. (Natural size.)

Occurs in the Jerid, especially at El Hamma, but appears to be uncommon. Is readily distinguished from other dry dates by being generally distinctly constricted a little above the base; hence resembling Boo Fagoos (see p. 67) in shape. Flesh firm, moderately sweet, with an agreeable flavor resembling that of Thaby (see p. 75), to which this variety appears to be closely related. Said to ripen early (in October) and not to be injured by autumn rains. Number of offshoots imported, 10.

HAMRA (p. 98).—The name means "red." Sometimes called Hamraia (referring to the tree rather than the fruit).[a] Fruit 1½ to 2 inches long, about one-half as wide, egg-shaped, tapering from near the base to the rounded apex, bright purplish maroon when ripe, the colors very handsome; the flesh 1 to 3 lines thick, becoming quite firm, the dark-colored outer zone thicker than the white central portion; the seed two-thirds to four-fifths as long as the fruit, generally about two-fifths as wide as long, sometimes with strongly developed wing-like ridges on the sides. (Fig. 34.) The stalks and branches of the fruit clusters are orange colored.

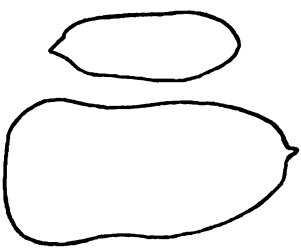

FIG. 33.—Outlines of Remta seed and fruit. (Natural size.)

Fairly common in the Jerid and the Nefzaoua, occurring also in Algeria. Is one of the largest and most showy of the dry dates. Much resembles Horra (see p. 71) and surpasses it in brightness of

[a] Hamra Bischry (or Bechry) is said by some of the natives of the Jerid to be identical with Hamra, although described in Algeria as a soft date. The "Hamraya" of the Mzab oases is also described as a soft date.

color, but is decidedly inferior to it in flavor. Ripens in the latter part of October and the beginning of November. Is not much esteemed by the natives. Said to keep well, having been enumerated at Kebili among the seven best preserving sorts. Number of offshoots imported, 4, all from the Jerid.

KENTEESHY (p. 99).—Also spelled Kentichi. Is known in Algeria as M'Kentichi Degla. Fruit about 1½ inches long, slightly more than one-half as wide, oblong or slightly inversely egg-shaped, dull bay when ripe, the skin remaining yellow; the flesh, 1 to 2½ lines thick, becoming hard and dry; the seed about two-thirds as long as the fruit, one-third to two-fifths as wide as long, broad and rounded at both ends. (Fig. 35.) The stalks and branches of the fruit clusters are dull orange. The palm is strong and vigorous, with coarse, heavy foliage, long leaves and numerous but rather distant long and broad leaflets. The stalks of the fruit clusters are curved,

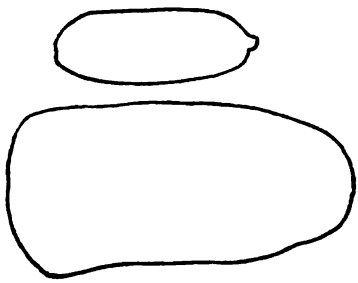

FIG. 34.—Outlines of Hamra seed and fruit. (Natural size.)

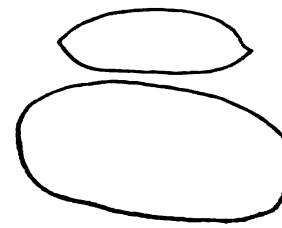

FIG. 35.—Outlines of Kenteeshy seed and fruit. (Natural size.)

forming nearly a semicircle, but do not hang down below the foliage.

Fairly common in the Jerid and much esteemed by the natives, who are reluctant to part with offshoots, notwithstanding the fact that the fruit is small, thin of flesh, and becomes hard and dry almost before it has lost its astringency. It ripens toward the end of October and beginning of November. It is moderately sweet and rather tasteless. It yields heavily, being one of the most productive varieties found in Tunis, and is said to give a good crop every year. It is reputed to be very alkali resistant, but to require plenty of water. Kenteeshy is said to thrive in poor soils where other varieties will not grow and to be often planted as a wind-break. Number of offshoots imported, 11, all from the Jerid.

SOFT DATES.

TANTABOOSHT (p. 99).—French orthography, Tantaboucht. Fruit nearly spherical, usually somewhat wider than long, 1 to 1½ inches in greatest diameter, usually widest above the middle, slightly depressed

at apex, not keeping its shape well when preserved, very dark brown purple (almost black) when ripe; the flesh 3 to 5 lines thick, very soft and dark colored; the large seed two-thirds to four-fifths as long as the fruit, one-half to two-thirds as wide as long, smooth. (Fig. 36.) The stalks and branches of the fruit clusters are deep orange colored.

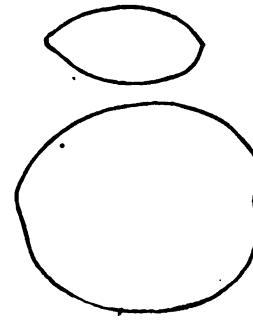

FIG. 36.—Outlines of Tantaboosht seed and fruit. (Natural size.)

Rare in the Jerid, common in Algeria. A date remarkable for its round shape and very soft, almost black flesh. Flavor peculiar and characteristic, even perfectly ripe fruit retaining a certain amount of astringency. Number of offshoots imported (from the Jerid), 5.

TOZER ZAID SAFRA [a] (p. 100).—Fruit 1½ to 1¾ inches long, one-half to two-thirds as wide as long, oblong or oblong egg-shaped, widest near the middle, broad, and rounded at apex, not keeping its shape well when preserved; the flesh 1½ lines thick, extremely soft and sirupy, nearly black; the relatively large seed about one-half as long as the fruit, two-fifths to one-half as wide as long, light brown. (Fig. 37.) The leaves are long and very numerous, with short stalks, almost concealing the fruit clusters.

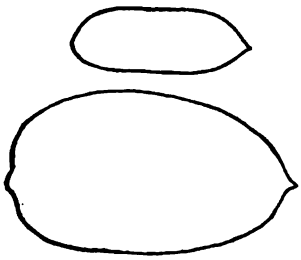

FIG. 37.—Outlines of Tozer Zaid Safra seed and fruit. (Natural size.)

Common in the Jerid. Flavor characteristic, resembling that of Baydh Hammam (p. 76), not attractive to the writer, but much appreciated by the natives. Generally eaten fresh, but sometimes preserved for a short time in skins. Yields heavily. Fruit ripens in the latter part of October. Said at Nefta to be one of the four most salt-resistant varieties. Number of offshoots imported, 9.

TOZER ZAID KHALA [b] (p. 100).—Fruit 1½ to 1¾ inches long, three-fifths to two-thirds as wide, inversely egg-shaped or oblong, broad and rounded at apex, not keeping its shape well

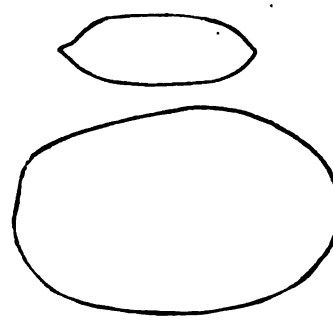

FIG. 38.—Outlines of Tozer Zaid Khala seed and fruit. (Natural size.)

[a] The very similar name "Taser Seit" is applied to a variety occurring in the Mzab oasis.

[b] Said to be known as Abdul Aziz (or Abd-el-Azaz) in the Oued Souf. A variety of the latter name occurs in the Oued Rirh.

soft and sirupy, nearly black; the seed about two-fifths as long as the fruit, about two-fifths as wide as long, dark brown. (Fig. 38.)

Less common than the Tozer Zaid Safra variety, which it very closely resembles in appearance and flavor. Number of offshoots imported, 7.

SAYBA BOO DRA (p. 102).—Fruit from 2 to more than 2½ inches long, less than one-half as wide, oblong, somewhat pointed at the apex, usually curved, prune purple when ripe, the surface rather dull; the flesh 3 to 3½ lines thick, rather firm; the slender seed about one-half as long as the fruit and not more than one-third as wide as long. (Fig. 39.) The stalks and branches of the fruit clusters are bright orange colored.

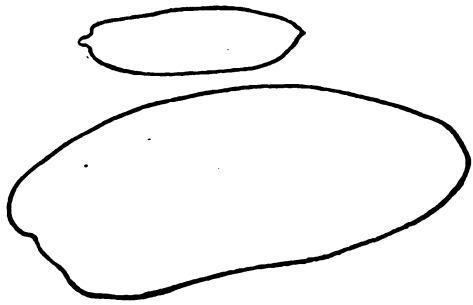

FIG. 39.—Outlines of Sayba Boo Dra seed and fruit. (Natural size.)

In Tunis apparently confined to the Jerid oases, where it is rare. Occurs also in the Oued Rirh in Algeria. The name signifies that, turned over endwise seven times, the fruit measures a cubit (20 inches), and is expressive of the great length of this huge date, the largest of the Tunisian varieties. Flesh thick, rather tough. Flavor agreeable, suggesting Boo Fagoos (see p. 67). It ripens about the end of October. Number of offshoots imported, 10.

KHAROOBY (p. 102).—French orthography, Kharroubi. Fruit about 2 inches long, less than two-fifths as wide, often wider near the apex than elsewhere, usually curved, between bay and maroon colored when ripe, the surface shiny; the skin conspicuously loosened and remaining light yellow; the flesh 1 to 2 lines thick, rather soft and dark colored; the seed nearly three-fifths as long as the fruit, one-third as wide as long, generally somewhat curved. (Fig. 40.) The stalks and branches of the fruit clusters are orange colored. The leaves are very long, crowded with long, broad leaflets.

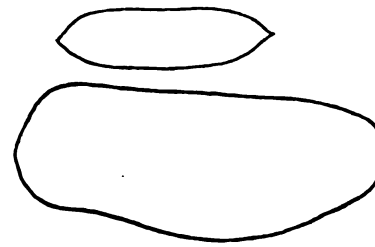

FIG. 40.—Outlines of Kharooby seed and fruit. (Natural size.)

Frequent, but not abundant, in the Jerid. Flesh of the ripe fruit of the consistency of thick jelly, moderately sweet, agreeable in flavor, resembling Lagoo (see p. 80). Said to preserve well. Ripens

in October. The offshoots remain small while attached to the parent tree. Number of offshoots imported, 2.

GASBY (p. 102).—Fruit about 2 inches long, about two-fifths as wide, oblong, often conspicuously curved, very dark prune purple with a conspicuous bloom when ripe, the surface dull, the skin tough, russet brown where loosened from the flesh; the flesh 1 line thick, dark colored, remaining soft; the slender seed not more than three-fifths as long as the fruit, not more than one-third as wide as long, russet brown, often curved. (Fig. 41.) The stalks and branches of the fruit clusters are deep orange colored. The crown of foliage is rather small and delicate, the leaves short, relatively long stalked, the leaflets long. The offshoots remain small while attached to the parent tree.

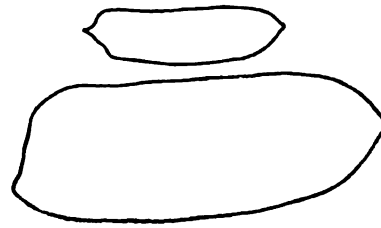

FIG. 41.—Outlines of Gasby seed and fruit. (Natural size.)

Common in the Jerid. Ripens very early, next after Ammary (see below), it is said; at the end of July, according to Masselot. A handsome, long, slender, dark-colored, generally curved date. Highly esteemed by some of the natives, while others say it is used mostly for making puddings and confectionery. The writer found its flavor, which is of the Lagoo type (see p. 80), rather attractive, suggesting that of raisins. It is said to keep very well. Number of offshoots imported, 19.

BENT SEGNY (p. 103).—Fruit $1\frac{3}{4}$ to $1\frac{7}{8}$ inches long, about one-half as wide, inversely egg-shaped, square at base, rounded at the apex, keeping its shape poorly when preserved, very dark (almost black) purplish brown when ripe; the flesh $1\frac{1}{2}$ lines thick, very dark colored and very soft; the seed about one-half as long as the fruit, two-fifths to one-half as wide as long, rounded at both ends. (Fig. 42.) The stalks and branches of the fruit clusters are deep orange colored.

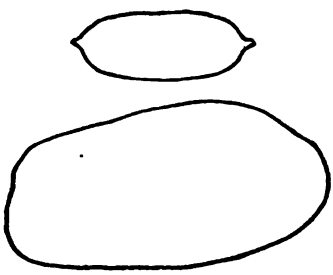

FIG. 42.—Outlines of Bent Segny seed and fruit. (Natural size.)

Rather rare in the Jerid. A very soft, sirupy date, with a pleasant but not remarkable flavor. Ripens about the end of October. Number of offshoots imported, 3.

AMMARY (p. 103).—Fruit $1\frac{1}{4}$ to a little over $1\frac{1}{2}$ inches long, about one-half as wide, generally inversely egg-shaped, square at the base, rounded at the apex, keeping its shape fairly well when preserved; dark brown purple when ripe; the flesh 1 to $1\frac{1}{2}$ lines thick, very soft

and dark colored; the seed about two-thirds as long as the fruit, about two-fifths as wide as long, blunt at both ends. (Fig. 43.) The stalks and branches of the fruit clusters are orange colored. Foliage coarse and heavy, leaves very numerous, rather short stalked, with long, wide leaflets.

Common in the Jerid, the Nefzaoua, at Gabes, and in Algeria. Is the earliest maturing variety in Tunis, ripening in the Jerid in August (or even the middle of July, according to Masselot), and from September 1 to September 15 at Gabes. Said to give a good crop every year, and to be very productive. Fruit of rather mediocre quality. Number of offshoots imported, 12, all from the Jerid.

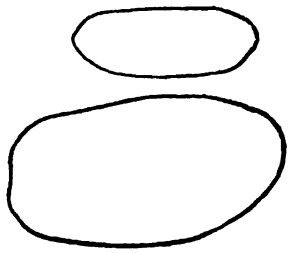

FIG. 43.—Outlines of Ammary seed and fruit. (Natural size.)

GOONDY (p. 103).—Fruit about 1⅔ inches long, about one-half as wide, inversely egg-shaped, oblong (broadest above the middle), keeping its shape fairly well when preserved, bay to maroon colored when ripe; the flesh about 1½ lines thick, dark colored, remaining rather soft; the seed more than one-half as long as the fruit, about one-third as wide as long. (Fig. 44.) The stalks and branches of the fruit clusters are bright orange colored. Foliage rather coarse, the leaves very numerous, short, and rather short stalked, the leaflets long and broad.

Rather common in the Jerid, and said to occur also in the Nefzaoua and at Biskra, in Algeria. Sweet and of agreeable but not pronounced flavor, of the Lagoo type. (See p. 80.) Ripens in the Jerid on October 20, according to Masselot, although the writer was told that it ripens sometimes as early as September 15. The fruit is preserved in skin bags for home use, but is not an article of commerce. Number of offshoots imported, 9, all from the Jerid.

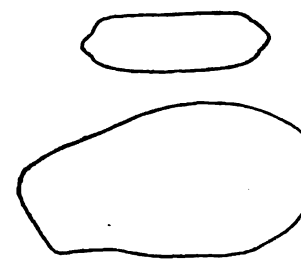

FIG. 44.—Outlines of Goondy seed and fruit. (Natural size.)

KAROOY (p. 104).—Fruit 1⅔ inches long, about one-half as wide, egg-shaped, narrowed from near the base to the rounded apex, keeping its shape fairly well when preserved, bay colored when ripe; skin, where loose, olive-brown; the flesh about 1½ lines thick, rather tough; the seed more than one-half as long as the fruit, about one-third as wide as long. (Fig. 45.) The branches and stalks of the fruit clusters are orange colored.

A variety found in the Jerid, but not common. The name is not given in any published list of the varieties. Flesh rather tough,

moderately sweet, flavor agreeable, similar to that of the dry dates. Number of offshoots imported, 5.

TENASEEN (p. 105).—French orthography, Tanessin or Tenassine.) Fruit $1\frac{2}{3}$ to $1\frac{7}{8}$ inches long, about one-half as wide, oblong, not keeping its shape well when preserved, black when ripe; the flesh very soft, nearly black; the seed about three-fifths as long as the fruit, about one-third as wide as long, rather dark brown.

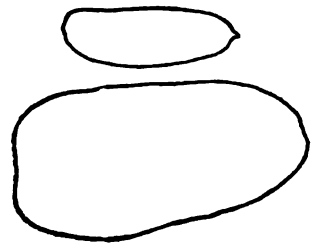

FIG. 45.—Outlines of Karooy seed and fruit. (Natural size.)

Rare in the Jerid, common in the Oued Souf and Oued Rirh in Algeria. The flavor of the very sweet, soft, dark-colored flesh suggests Tozer Zaid Safra (see p. 85), but is more agreeable. Is said to ripen in October. Crown of foliage horizontal, umbrella-like. One offshoot imported from the Jerid.

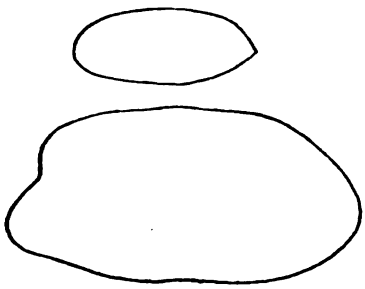

FIG. 46.—Outlines of Iteema seed and fruit. (Natural size.)

ITEEMA (p. 106).—(French orthography, Ytima.) The name means "an orphan girl." Fruit slightly more than 2 inches long, about one-half as wide, widest at or near the middle, rounded at base, somewhat pointed and conspicuously not symmetrical at apex, not keeping its shape well when preserved, chestnut brown, with a slight purple tinge when ripe, the surface shiny; the flesh over 2 lines thick, extremely soft; the seed nearly one-half as long as the fruit, about two-fifths as wide as long, chestnut colored. (Fig. 46.)

Rare in the Jerid, common in the Algerian oases. A very handsome date, with sirupy, translucent flesh, extremely sweet, rather insipid in flavor. An early ripening sort, maturing in the Jerid at the end of September (according to Masselot). Eaten fresh. Number of offshoots imported, 15 (2 only from Tunis, the rest from Algeria).

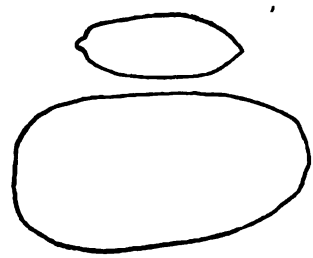

FIG. 47.—Outlines of Khalt Hameed seed and fruit. (Natural size.)

KHALT HAMEED (p. 106).—Fruit $1\frac{2}{3}$ inches long, about one-half as wide, elliptical in form, generally slightly narrowed at both ends, keeping its shape well when preserved, bright maroon when ripe; the flesh $1\frac{1}{2}$ lines thick, rather firm, not very sugary; the seed smooth, more than one-half as long as the fruit, about two-fifths as wide as long, widest above the middle. (Fig. 47.)

Occurs in the Jerid, but is not common. Said to be much liked by the natives when not perfectly ripe, but to the writer the flavor seemed inferior. Ripens at the end of October. Does not keep. Number of offshoots imported, 6.

VARIETIES IMPORTED BUT NOT INCLUDED IN THE KEY.

Deglet Barca.—Occurs in the Jerid, but is not common. Fruit not seen by the writer, but said to be round, of the same color as Tozer Zaid Safra (p. 85) (very dark brown, almost black), but different in flavor. It is described as a R'tob (soft date) that preserves very well. Number of offshoots imported, 7.

Deglet Caid.—Rare in the Jerid, and said to occur also in the Oued Rirh. Fruit not seen by the writer, but said to be coral red before maturity and black when ripe, and to be conservable only for a short time. Reported to be a fine variety, and to ripen early in September. Number of offshoots imported, 2.

Deglet Sennayga.—Occurs in the Jerid; not common. A soft date. Fruit about 1½ inches long, nearly one-half as wide, oblong, somewhat pointed at the apex, bright chestnut brown when ripe, surface shiny; skin much loosened and folded; flesh soft, dark colored; seed large, dark brown. Said to ripen early in October. Very sweet, flavor distinctive (suggesting burnt sugar) and rather agreeable, but not very pronounced. It is said to keep well. The offshoots remain small as long as they are attached to the parent tree. Number of offshoots imported, 9.

Gasb Haloo.—(Name spelled phonetically, as pronounced by the natives.) Occurs at Nefta. Is probably the same as the "Gsub (or Ksob) Halou" found in the Ziban and Oued Rirh oases of Algeria. Fruit not seen by the writer. Said to resemble Kenteeshy (p. 84) in color; described as sweeter and better flavored than Gasby (p. 87). Number of offshoots imported, 3.

Guern-el-Rhezal.—(Gazelle's Horn.) One of the principal varieties in the Gabes region and on the island of Jerba, occurring also at Biskra and in the Oued Rirh, Algeria, but rare in the Jerid. Fruit not seen by the writer. It is described by M. Minangoin as long, slender, and curved. The amins at Gabes say it is not a very good date, the stone being large and the flesh thin. "It has more bones than flesh," as they express it. This is said, however, to be one of the three varieties chiefly preserved at Mettoui, near Gabes, requiring first to be dried. Number of offshoots imported, 4.

Khadraya.—Name signifies "green." Occurs in the Jerid, but apparently is not common. A variety of the same name, but perhaps not identical, is found in Algeria. Belongs to the dry date class.

Fruit about 1½ inches long, about one-half as wide; oblong, narrowed at the apex, bright orange before maturity, dull light brown when ripe; seed large, light brown; branches of fruit clusters bright orange. Very sweet and with a pleasant flavor, suggesting Haloba Bayda (see p. 75). Ripens in October. Number of offshoots imported, 5.

KHALT BOO FAGOOS.—A rare variety of the Jerid. Fruit of the soft type, very similar to that of Boo Fagoos (see p. 67), about 1⅔ inches long, 1 inch wide, generally more or less obovate, maroon colored when ripe, skin much blistered; flesh very firm; seed large; branches of fruit clusters light orange. Moderately sweet, with a fine flavor of the Horra type (see p. 71). Number of offshoots imported, 4.

KHALT GAMA.—Occurs at Nefta. Fruit not seen by the writer. "Gama" means wheat, and the name is said to refer to the color of the fruit. Number of offshoots imported, 2.

KHALT KEBEER.—A variety of the Jerid, apparently not common. A fine, large, reddish brown, soft date, with small seed, preserving admirably. Flavor excellent, considered by the natives to resemble that of Boo Fagoos (see p. 67). Is a promising variety. Number of offshoots imported, 11.

KHALT KENTAOWIA.—Occurs in the Jerid; apparently not uncommon at Tozer. Fruit not seen by the writer. The foliage is well developed and handsome, the leaves very numerous, crowded with long leaflets. The name implies a resemblance to the Kenta variety (p. 72). Number of offshoots imported, 4.

OKHT AMMARY.—A variety of the Jerid, probably not common. Fruit not seen by the writer. Said to resemble Ammary (see p. 87), but to be larger. Reported to ripen at the end of September, and not to keep well. One offshoot was imported.

SBA AROOSSA.—Name means "bride's fingers." Occurs in the Jerid, and also reported to occur in the Ziban oases, in Algeria. Is said to be rare and of fairly good quality. Fruit not seen by the writer. Reported to be a long, slender date, ripening in October and not keeping well. Number of offshoots imported, 6.

TOWADANT.—Occurs at Nefta, and is probably rare. Fruit not seen by the writer; said to be very large and long, yellow, and of good flavor, ripening at the same time as Fteemy, and keeping well. Number of offshoots imported, 4.

ZRAI.—Name spelled phonetically as pronounced by the natives, not having been found in any published list. Occurs at Nefta. Fruit not seen by the writer; said to resemble Deglet Noor (p. 63) in color. Number of offshoots imported, 7.

CHEDAKH (p. 106).—Is of the soft type. Fruit nearly 2 inches long, about one-half as wide, oblong, narrowed slightly at both ends, keeping its shape fairly well when preserved, purplish maroon when ripe; the flesh only 1 line thick, all of it soft and dark colored; the seed about three-fifths as long as the fruit and about one-third as wide as long. (Fig. 48.) The leaves are rather short, and the fruit clusters loose and open, with rather short, erect or ascending stalks.

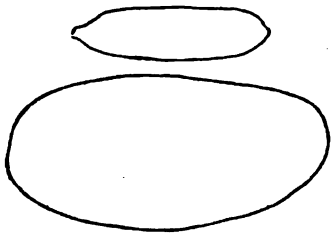

FIG. 48.—Outlines of Chedakh seed and fruit. (Natural size.)

Common in the Jerid, and said also to occur in the Nefzaoua. Is a "R'tob," the fruit being eaten fresh and not preserved. It is not highly esteemed by the natives, and the flavor is uninteresting. Ripens toward the end of October.

DEGLET HAMIDATOO (p. 105).—Fruit of the soft type, about 2 inches long, about one-half as wide, somewhat blunt pointed at the apex, elliptical, not keeping its shape well when preserved, light hazel brown when ripe; the flesh 2½ lines thick, very soft and sirupy, translucent; the seed about one-half as long as the fruit, about one-third as wide as long, russet to chestnut colored. (Fig. 49.) The foliage is very well developed, the leaves numerous and long, crowded with long leaflets, the bunches of fruit rather loose and open, with ascending or spreading stalks.

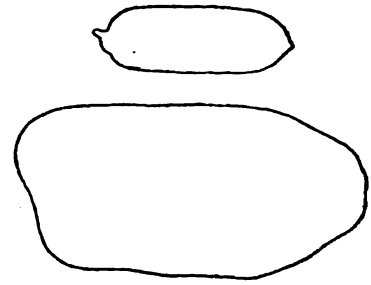

FIG. 49.—Outlines of Deglet Hamidatoo seed and fruit. (Natural size.)

A very rare variety of the Jerid, said to be represented at Tozer by only two trees. Reported to occur also in the oasis of Negrine, Algeria. It is said to be eaten only when fresh and not to be conservable. The fruit is of splendid appearance, beautifully colored, and extremely soft and sirupy when ripe. Although very sweet and rich, the flavor is rather insipid and soon cloys, like the Iteema (p. 89). Ripens in the latter part of October.

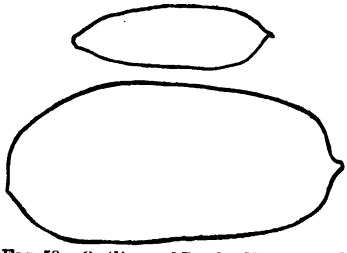

FIG. 50.—Outlines of Deglet Hassen seed and fruit. (Natural size.)

DEGLET HASSEN (p. 103).—Fruit of the soft type, 1⅔ to 1¾ inches long, one-half as wide, inversely egg-shaped, tapering slightly at both extremities, not keeping its shape well when preserved, bright bay

colored when ripe; the skin, where loose, yellow; the flesh about 1½ lines thick, extremely soft, light colored, translucent; the slender seed about three-fifths as long as the fruit, not more than one-third as wide as long. (Fig. 50.) The trunk is slender, the leaves numerous, short, and comparatively long-stalked.

Said to be widely distributed in the Jerid, although the writer failed to secure offshoots. The offshoots are said to be worth 75 cents to $1.15 apiece, a price that would indicate this to be a highly esteemed variety. The fruit, said to be eaten only when fresh, is extremely soft and very sweet and rich, but soon cloys. Ripens in October.

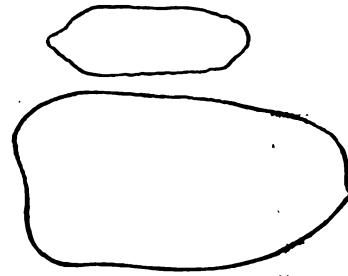

FIG. 51.—Outlines of Khalt Menakhry seed and fruit. (Natural size.)

KHALT MENAKHRY (p. 105).—The name signifies a "Khalt resembling Menakher."[a] Fruit of the soft type, from nearly to more than 2 inches long, about one-half as wide, egg-shaped, narrowed from about the middle to the broad, rounded apex, keeping its shape well when preserved, dark purplish maroon when ripe; the flesh 2 to 3 lines thick, firm, yet very sugary; the seed about one-half as long as the fruit, about two-fifths as wide as long, blunt at both ends. (Fig. 51.) The stalks and branches of the fruit clusters are light orange colored.

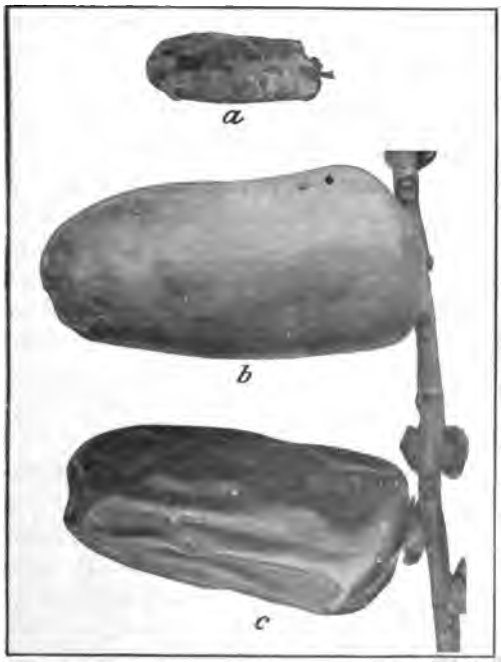

FIG. 52.—Selatny seed and fruits. (Natural size.)

Occurs at Nefta, in the Jerid, but is evidently very rare. The fine fruit very closely resembles Khalt Horraowia (p. 82) in appearance and flavor. Ripens in the latter part of October.

SELATNY (p. 104).—Fruit of the soft type, over 2 inches long, about one-half as wide, tapering from near the base to the somewhat pointed apex, keeping its shape well when preserved, bright bay colored when

[a] See footnote, p. 81.

ripe, the surface shining; the flesh 1½ lines thick, rather soft, translucent; the seed about one-half as long as the fruit, about two-fifths as wide as long, blunt at both ends, roughened with deep furrows near the base. (Fig. 52.) The stalks and branches of the fruit clusters are orange colored.

A rare variety of the Jerid; said also to occur in the Nefzaoua, and to be less rare there, although the writer saw no trees in the latter region. It is very highly esteemed by the natives and, although a special effort was made to obtain offshoots of this variety in the Jerid, none could be had. It is possible that an exhaustive search in the Nefzaoua region might result in obtaining offshoots. The fruit is of fine appearance and is said to be generally eaten fresh, although it can be preserved. The flavor somewhat resembles that of the Deglet Noor and is hardly inferior, while in size this variety compares favorably with the Menakher. It ripens in October (or even in September, according to Masselot). The palm has a stout trunk. The leaves are rather short and broad, with few spines. The stalks of the short fruit clusters are nearly horizontal and so short that together with the clusters they are hardly as long as the leafstalks. For the rarity of this variety the same explanation was given the writer as for that of Menakher (see p. 62).

DESCRIPTIVE KEY TO THE CHARACTERS OF THE FRUITS.

The characters given in the key of date varieties which follows were either noted on the spot from freshly gathered fruit or were subsequently worked out from samples and from natural-size photographs made in the field. In a few instances samples of fruit obtained in the autumn of 1905 at the cooperative date garden at Tempe, Ariz., from palms imported several years ago from Algeria, have also been used in making up the descriptions, such cases being always specifically mentioned. Owing to the scantiness of the material available in many cases, it is probable that the descriptions will have to be modified as we gain a better knowledge of the varieties.

In regard to measurements, width refers in every case to the greatest width of the fruit and the seed, thickness of flesh to the maximum thickness, and length of the stone is taken to exclude the apical point, or mucro, and the fibrous stipe. Color of the fruit, unless otherwise specified, refers to the parts where the skin adheres closely to the flesh. Where the skin has become loose in places, as in most of the soft dates when quite ripe, it has a lighter color, which is also generally described. The "germ pore" is a circular depression, 1 to 2 mm. in diameter, occurring on the back of the seed. When its position is not mentioned in the description it is understood that it occurs at or near the middle of the seed. The embryo is situated at this point and the shoot appears here at germination.

Much use has been made of the characters afforded by the colors of the fruit, seed, etc., the names of colors used being those given by Ridgway (Nomenclature of Colors for Naturalists, Boston, 1886). In order to facilitate comparison, each name of a color that occurs in the key is followed by a reference to the corresponding plate and figure in the work cited, thus: Maroon (IV, 2). The giant cells, to which the writer's attention was first called by Mr. W. T. Swingle, occur in a more or less sharply defined zone in the softer part of the flesh, close to the skin. It is really the hard, bright-colored, highly refractive masses of cell contents (probably consisting chiefly of tannins) that are here described. Their characters are taken only from thoroughly ripe fruit in which the cell contents have assumed their final shape, size, and color.

A word is necessary in regard to the form of the key. The varieties are divided, in the "Synopsis of the groups," first into two principal classes, the dry dates and the soft dates. Each group is then subdivided into a number of smaller groups. The designations selected for the two main groups should not be understood as implying that all the dry dates are necessarily hard and thin of flesh or that all the soft dates are rich and sirupy. While the extremes of the two types are very distinct, intermediate forms occur, which make it impossible to draw a hard and fast line between them. Exceptions occur in both categories, and some of the varieties of which the affinities are evidently with the first group have thicker and softer flesh than some of the varieties of the second group. In deciding to which of the two classes a given variety belongs, all of its characters must be taken into consideration. It should be explained that the classification, at least beyond the two main groups, is largely artificial, and is designed merely to aid in identifying the varieties. While in many cases it happens that several varieties that are undoubtedly closely related botanically are brought into juxtaposition in the key, this is by no means always the case.

The key to the varieties is not of the dichotomous form usually employed by systematic biologists, but is modeled upon that which was introduced by Mr. O. F. Cook in his studies of Myriapoda.[a] It has the advantage of eliminating one species (or variety) at every step. It will be noted that the whole key is arranged in pairs of paragraphs. Of each pair, the first paragraph describes a variety, and the second gives the characters which distinguish all of the same group which follow from the one that has just been separated out. Those characters in the first paragraph that are especially to be con-

[a] In a paper published in the Annals of the New York Academy of Science, 9, p. 8 (1895), a key of this style was first used by Mr. Cook. See also Proc. U. S. Nat. Mus., 18, p. 82 (1895).

trasted with the second paragraph are printed in italics, as is the second paragraph itself. The italicized portion, therefore, constitutes the key proper. Frequently an alternative set of characters, introduced by the words "or if," will be found in the second paragraph of the pair (as on p. 101). These alternative characters generally refer to the variety described in the first paragraph that immediately follows.

It is believed that by including in the key the complete description of each variety, the identification can be made with more confidence than if only the characters necessary for "keying out" the varieties were given. While the construction of a key of this type presents difficulties that are not encountered in making the ordinary dichotomous key, it is believed that the user, after a little practice, will find it more serviceable. He will have the satisfaction, as it were, of touching ground at each step he takes.

After the name of each variety, at the end of the paragraph describing it, is given a reference to the page of the text on which will be found outlines of the seed and fruit.

1. Synopsis of the Groups.

* Flesh becoming quite dry and often hard, the white central portion thicker than the darker colored, softer outer portion (often twice as thick);[a] the fibrous lining of the central cavity clean and dry, bright white; giant cells in a more or less sharply defined zone lying between the white and the dark flesh, very small, generally not much longer than wide.
Dry dates.

** Skin becoming loose over much of the surface of the fruit, forming large, smooth, soft, mostly longitudinal blisters.
Smooth-skinned dry dates, p. 97.

** Skin closely adhering to most of the surface of the fruit, forming a network of narrow, hard, transverse as well as longitudinal wrinkles, with few or no large, soft blisters.
Wrinkled dry dates, pp. 97 to 99.

* Flesh not becoming dry and hard, the white central portion thinner than the dark colored, softer outer portion; the fibrous lining of the central cavity usually more or less soaked and darkened with sirupy juice; zone of giant cells not usually sharply defined (or at least not easily distinguishable in color) from the zone outside it, the cells usually variable in size and shape; skin becoming loosened over much of the surface of the fruit when ripe,[b] forming large, soft, generally longitudinal blisters, but otherwise smooth; or, if forming also a network of narrow transverse wrinkles, these few and soft ..... Soft dates.

** Fruit spherical or nearly so, at least three-fourths as wide as long.
Round soft dates, p. 99.

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[a] Exceptions are the varieties Bayjoo (p. 97), Thaby (p. 98) and Hamra (p. 98) in which the darker colored outer zone is much thicker than the white inner zone, at least in fruits that have been kept for some time. In other respects these are typical dry dates, having the clean, bright white lining of the central cavity and the skin covered with a network of hard, narrow wrinkles.

[b] The Khalt Mooashem variety (see p. 104) is an exception in having the skin closely adhering.

** Fruit not spherical or nearly so.
*** Fruit at least 3 mm. shorter than twice the width.
Broad soft dates.
**** Flesh dark colored, very soft and sirupy, date not keeping its shape well when ripe.
Sirupy broad soft dates. pp. 99–100.
**** Flesh rather firm, not sirupy, date keeping its shape well when ripe..... Firm broad soft dates, pp. 100–101.
*** Fruit at least 3 mm. longer than twice the width.
Narrow soft dates, pp. 101–102.
*** Fruit about twice as long as wide..... Intermediate soft dates.
**** Decidedly wider near the apex than at base.
Obovate intermediate soft dates, p. 103.
**** Decidedly wider at the base than near the apex, tapering from near or below the middle to the apex.
Ovate intermediate soft dates, pp. 103 to 105.
**** As wide or nearly as wide at the apex as at the base, either widest at or near the middle or else of about the same width throughout.
Oblong intermediate soft dates, pp. 105–106.

2. Key to the Varieties.

Dry Dates.

SMOOTH-SKINNED DRY DATES.

Fruit only 25 mm. long (smallest of the Tunisian varieties), *about 17.5 mm. wide*, ovate or obovate, bright bay (IV, 5) when ripe, the skin ochraceous (V, 7) to cinnamon rufous (IV, 16); *flesh 2.5 mm. thick*, becoming hard and dry, more than one-half of it consisting of the white central portion; seed 18 mm. long, about 9 mm. wide, smooth, drab brown (III, 18), the ventral channel narrow, open, the germ pore generally considerably above the middle; giant cells in a sharply defined zone forming about one-half the thickness of the dark outer part of the flesh, very small, nearly all rounded, rarely more than 1½ times as long as wide, mostly spherical but some elliptical and pear-shaped, orange colored; *branches of the fruit clusters bright (lemon) yellow*..... *Angoo* (p. 74).

Fruit 35 to 40 mm. long, about one-half as wide, often slightly wider just above the middle than elsewhere, then narrowed to the truncate or blunt-pointed apex, dull bay (IV, 5) colored when ripe, the skin rufous (IV, 7) to hazel (IV, 12) colored; *flesh 3 to 4 mm. thick*, not becoming very dry; seed 21 to 25 mm. long, one-third to two-fifths as wide, rounded at both ends, Isabella brown (III, 23) in color, the ventral channel narrow, open, the germ pore above the middle; giant cells very uniform in size and shape, spherical or nearly so, rufous (IV, 7) colored; *branches of the fruit clusters light orange*..... *Kenta* (p. 73).

WRINKLED DRY DATES.

Fruit about 32.5 mm. long, three-fifths to two-thirds as wide, ovate in outline, dull orange yellow before maturity, purplish maroon (IV, 2) or bay (IV, 5) colored when ripe; flesh 3 mm. thick, the white central portion much thicker than the dark outer zone;[a] *seed* averaging 20 mm. long and *10 mm. wide*, Isabella brown (III, 23), the ventral channel wide, open, the *germ pore near the apex of the seed*, conspicuous; *giant cells* very small, *all rounded, nearly all spherical*, orange rufous (IV, 13) in color; branches of the fruit clusters pale orange..... *Bayjoo* (p. 83).

Fruit only about twice as long as wide.

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[a] Although in fruits cut open several weeks after gathering the converse appears to be true, owing to the suffusion of the white zone with sirup from the dark portion.

when ripe; flesh 2.5 to 5 mm. thick, becoming hard and dry; seed about two-thirds as long as the fruit, one-third to two-fifths as wide as long, broad and rounded at both ends, between russet (III, 16) and wood brown (III, 19), the ventral channel open; branches of the fruit clusters orange buff (VI, 22)---------- *Kenteeshy*[a] (p. 84).

Skin, where loose, russet (III, 16); *giant-cell zone less sharply defined, with groups of these cells extending through the outer layer of flesh nearly to the skin.*

Ripe fruit dull purplish maroon (IV, 2), with considerable bloom, *35 to 40 mm. long*, often somewhat curved; flesh 2.5 to 4 mm. thick; seed about two-thirds as long as the fruit, generally one-third as wide as long, the ventral channel open; *giant cells wax yellow* (VI, 7); branches of the fruit clusters orange colored----------*Lemsy* (p. 75).

Ripe fruit dull bay (IV, 5) (dull Indian purple (VIII, 6) toward base), with considerable bloom, *32.5 to 35 mm. long;* flesh 2 to 3 mm. thick; seed about seven-tenths as long as the fruit, one-third to two-fifths as wide as long, the ventral channel open; *giant cells tawny* (V, 1) *brown;* branches of the fruit clusters pale orange----------*Haloua Bayda*[b] (p. 76).

SOFT DATES.

ROUND SOFT DATES.

Fruit 35 to 45 mm. in greatest diameter, mostly longer than wide, spherical or nearly so, *keeping its shape well when preserved, color before maturity dull orange brown, between maroon* (IV, 2) *and prune purple* (VIII, 1) *when ripe;* skin, where loose, tawny (V, 1); *flesh firm*, 8 to 10 mm. thick; *seed* very thick, six-tenths to seven-tenths as long as the fruit, about three-fifths as wide as long, *conspicuously roughened with longitudinal and transverse furrows*, the ventral channel closed, the germ pore not distinguishable; giant cells mostly spherical or quadrangular with rounded angles, rarely more than one and one-half times as long as wide, ferruginous (IV, 10) in color----------*Tronja* (p. 67).

Fruit 25 to 35 mm. in greatest diameter, usually somewhat wider than long, usually widest above the middle, often slightly depressed at the apex, *not keeping its shape well when preserved, deep chrome yellow* (VI, 8) *before maturity, very dark brown purple (almost black) when ripe; flesh very soft*, 6 to 10 mm. thick, very dark colored; *seed* two-thirds to four-fifths as long as the fruit, one-half to two-thirds as wide as long, mummy brown (III, 10) to russet (III, 16) color, *smooth*, the ventral channel nearly closed except near the apex; giant cells very variable in size and shape, spherical, elliptical or irregularly triangular or quadrangular with rounded angles, mostly one to one and one-half (rarely more than 2) times as long as wide, burnt umber (III, 8) colored; branches of the fruit clusters deep orange----------*Tantaboosht*[c] (p. 85).

BROAD SOFT DATES.

Sirupy Broad Soft Dates.

Fruit 32.5 to 35 mm. long, about three-fourths as wide, *very broad ovate, widest at the base and narrowed thence to the broad rounded apex, bright bay* (IV, 5) *colored* with a pronounced bloom *when ripe;* flesh very soft, about 3 mm. thick, translucent; seed wood brown (III, 19), one-half to two-thirds as long as the fruit, about one-half as wide as long, rounded at

[a] Description supplemented by fruit from the garden at Tempe, Ariz., from a palm originally from Biskra, Algeria.

[b] The fruits of young palms labeled *Haloua* in the Tempe garden, originally from Biskra, Algeria, differ from the above description in several particulars and probably belong to another variety. It should be noted that in Tunis the word Haloua (sweetmeat) occurs as a prefix in the names of several very different varieties of dates. Thus, Haloua Ch'eb, Haloua Teboolboo, etc.

[c] Description supplemented from the fruit of 3 palms in the Tempe, Ariz., date garden.

both ends, the ventral channel open throughout its length, the germ pore a little above the middle; giant cells mostly spherical, some short elliptical, a few angular, orange rufous (IV, 13) in color; branches of the fruit clusters light orange.....*Mokh Begry* (p. 76).

Fruit, wider at or above the middle than at the base, very dark brown or black when ripe.

Fruit ovate, rather abruptly narrowed near the somewhat pointed apex. 40 to 42.5 mm. long, from a little less to a little more than one-half as wide; bright orange before maturity, *dark chestnut* (IV, 9) *with a tinge of maroon* (IV, 2) *when ripe;* flesh about 4 mm. thick; seed 20 to 25 mm. long, one-third to two-fifths as wide, burnt umber color (III, 8), the ventral channel open, the germ pore above the middle; giant cells nearly all rounded, either spherical or short elliptical, one and one-half to two times as long as wide, tawny (V, 1) colored; branches of the fruit clusters orange..... *Baydh Hamman* (p. 77).

Fruit oblong or somewhat obovate, rounded at the broad apex, black or nearly so when ripe.

Fruit oblong or oblong ovate, 35 to 40 mm. long, generally more than one-half to two-thirds as wide, *bright orange before maturity, very dark brown (almost black) when ripe,* skin where loose raw umber (III, 14) colored; flesh 3 mm. thick; seed about one-half as long as the fruit, two-fifths to one-half as wide as long, *light brown (between Isabella* (III, 23) *and fawn* (III, 22) *color), the ventral channel open nearly or quite throughout its length, the germ pore considerably above the middle, very distinct; giant cells mostly angular* (quadrangular) but many spherical, ferruginous (IV, 10) in color.....*Tozer Zaid Safra* (p. 85).

Fruit generally oblong obovate, 37.5 to 42.5 mm. long, three-fifths to two-thirds as wide, *dark maroon* (IV, 2) *before maturity, black when ripe;* flesh about 4 mm. thick; seed about two-fifths as long as the fruit, two-fifths as wide as long, *burnt umber color* (III, 8) *the ventral channel almost completely closed, the dorsal circle at the middle, not very distinct; giant cells nearly all rounded,* mostly spherical, ferruginous (IV, 10) in color.....*Tozer Zaid Khala* (p. 85).

Firm Broad Soft Dates.

Flesh thin (not exceeding 2.5 mm. in thickness), becoming very firm and dry, more than half of it consisting of a white fibrous core, fruit 25 mm. long. *Angoo.*[a]

Flesh thick (at least 4 mm. in thickest part), not becoming very dry, the white fibrous core forming much less than half of its thickness, fruit at least 32.5 mm. long.

Skin loosening in a network of narrow wrinkles as well as large soft blisters, orange rufous (IV, 13) *where loose; fruit* 35 to 37.5 mm. long, ovate or oblong ovate in outline, *widest at or below the middle,* purplish maroon (IV, 2) or bay colored (IV, 5) when ripe; flesh 4 to 5 mm. thick, firm yet tender; seed averaging 22 mm. long and 9 mm. wide, russet (III, 16) colored, the ventral channel open; giant cells in a well-defined zone, very small, irregularly quadrangular with rounded angles, to nearly elliptical or spherical in outline, wax yellow (VI, 7) to orange (VI, 3) in color; branches of the fruit clusters deep orange.....*Kseba* (p. 77).

Skin loosening in large soft blisters but not developing a network of narrow wrinkles.

Fruit about 37.5 mm. long, 22 to 26 mm. wide, *ovate (widest near the base), the surface dull,* orange colored before maturity, between maroon (IV, 2) and prune purple (VIII, 1) when ripe; skin where loose ochraceous (V, 7) to russet (III, 16); flesh 3 to 4 mm. thick, the central white fibrous core forming nearly one-half the total thickness; seed 18 or 19 mm. long, 9 or 10 mm. wide, narrowed at both ends, the ventral channel frequently

[a] This is properly a dry date and is described on p. 97; but on account of its smooth, blistered rather than wrinkled skin it might be sought in this part of the key.

closed, the germ pore a little above the middle; giant cells mostly about as wide as long and angular (irregularly quadrangular, pentagonal, etc., with rounded angles), orange rufous (IV, 13) in color; branches of the fruit clusters light orange..... *Doonga* (p. 78).

Fruit oborate or oborate oblong (widest at or above the middle), its surface shining, at least 40 mm. long or, if shorter, the seed with more or less conspicuous wing-like lateral ridges.

Fruit 32.5 to 37.5 mm. long, about two-thirds as wide, bright bay (IV, 5) colored, the skin where loose tawny ochraceous (V, 4); flesh 4 mm. thick, light brown; *seed with more or less conspicuous lateral wing-like ridges,* two-thirds to three-fourths as long as the fruit, generally two-fifths as wide as long, broad at both ends, the ventral channel frequently closed; giant cells mostly spherical or very short elliptical, saffron yellow (VI, 4)..... *Besser Haloo* (p. 78).

Fruit 40 mm. or longer, the seed without wing-like ridges (although sometimes roughened).

Fruit somewhat fiddle-shaped, widest above the middle but often somewhat narrowed at the extreme apex, *constricted near the middle,* 40 to 45 mm. long, 22.5 to 25 mm. wide, greenish yellow before maturity, between maroon (IV, 2) and prune purple (VIII, 1) when ripe; skin where loose ochraceous (V, 7); flesh 5 mm. thick, firm but tender; seed about three-fifths as long as the fruit, about one-third as wide as long, the ventral channel open, germ pore small and inconspicuous; *giant cells all rounded, decidedly longer than wide, ferruginous* (IV, 10) *in color;* branches of the fruit clusters orange..... *Boo Fagoos* (p. 67).

Fruit not fiddle-shaped nor constricted near the middle, giant cells angular, about as wide as long, saffron yellow (VI, 4) *to light orange* (VI, 3) *in color.*

Fruit 45 to 50 mm. long, slightly more than one-half to three-fifths as wide, *conspicuously wider above than below the middle, then narrowed to the blunt apex, bright orange before maturity, bright purplish maroon* (IV, 2) *when ripe;* skin loose over much of the surface, ochraceous (V, 7) to ochraceous rufous (V, 5); flesh 6 to 7 mm. thick; seed 24 to 27 mm. long, about two-fifths as wide, cinnamon brown (III, 20), the ventral channel open; *branches of the fruit clusters deep orange.*
Boo Affar (p. 66).

Fruit 40 to 60 mm. long, one-half to two-thirds as wide, *only slightly wider above than below the middle, broad and rounded at apex, dull orange before maturity, light bay* (IV, 5) *or hazel* (IV, 12) *colored when ripe,* the skin in large part loose and conspicuously blistered in the ripe fruit, orange (VI, 3) to ochraceous (V, 7) in color; flesh 5 to 6 mm. thick; seed about one-half as long as the fruit, less than one-half as wide as long, cinnamon rufous (IV, 16) in color, its surface roughened here and there with irregular ridges and furrows, the ventral channel frequently closed, the germ pore above the middle; giant cells very diverse in shape and size, irregularly quadrangular, pear or cigar shaped, saffron (VI, 4) to orange (VI, 3) in color; *branches of the fruit clusters light orange.*
Areshty (p. 71).

NARROW SOFT DATES.

Skin conspicuously marked with short, linear scars, fruit 47.5 to 52.5 mm. long, 17.5 to 20 mm. wide, oblong, tapering slightly from base to apex, not curved or very slightly so, *bright bay* (IV, 5) *when ripe,* the skin where loose ochraceous (V, 7) colored; flesh 3 to 4 mm. thick, soft, translucent; seed 30 mm. long, about one-third as wide, the ventral channel sometimes closed, the germ pore considerably above the middle, very distinct; *giant cells* mostly 2 to 3 times as long as wide, *mostly angular or pointed,* raw sienna (V, 2) colored..... *Tafazween* (p. 68).

Skin not marked with linear scars, giant cells rounded, or, if angular, the fruit prune purple (VIII, 1) *when ripe.*

Fruit 50 to 62.5 mm. long, 22.5 to 27.5 mm. wide, oblong, somewhat pointed at apex, usually curved, greenish yellow before maturity, prune purple (VIII, 1) with considerable bloom when ripe; skin where loose russet

(III, 16), surface dull; *flesh 6 to 7 mm. thick*, rather tough; seed 25 to 30 mm. long, about one-third as wide, the ventral channel very open; *giant cells variable in shape, many angular or sharp pointed*, others spherical or elliptical, 1 to 3 times (the great majority 1 to 1½ times) as long as wide, ferruginous (IV, 10) in color; branches of the fruit clusters bright orange.....*Sayba Boo Dra* (p. 86).

Fruit not exceeding 52.5 mm. long, giant cells with rounded outlines, none or very few angular.

Fruit not curved, 50 to 52.5 mm. long, about 20 mm. wide, oblong, somewhat pointed, yellowish to reddish orange before maturity, *deep maroon* (IV, 2) *to prune purple* (VIII, 1) *when ripe*, the skin russet (III, 16) where loose, shiny; flesh 5 to 6 mm. thick, soft; seed slender, 23 to 26 mm. long, less than one-third as wide, between russet (III, 16) and burnt umber (III, 8) colored, the ventral channel narrow, open; giant cells mostly elliptical, many spherical, a few rod-shaped (more than twice as long as wide) none angular, deep ferruginous (IV, 10) in color; branches of the fruit clusters orange.....*Okht Fteemy* (p. 79).

Fruit more or less curved or, if straight, bay (IV, 5) *to light maroon* (IV, 2) *in color.*

Fruit straight or nearly so, 40 to 50 mm. long, two-fifths to nearly one-half as wide, oblong or somewhat obovate in outline, *not keeping its shape well when ripe*, conspicuously mucronate, orange before maturity, bay (IV, 5) colored when ripe, skin where loose russet (III, 16), shiny; *flesh 4 to 8 mm. thick, very soft and sirupy;* seed 25 to 28 mm. long, two-sevenths to one-third as wide, broad and rounded at both ends, ventral channel closed near the middle or open throughout; giant cells usually spherical but often short elliptical, never angular, rarely more than one and one-half times as long as wide, orange (VI, 3) to russet (III, 16) colored; branches of the fruit clusters bright orange.....*Rhars*[a] (p. 79).

Fruit more or less curved, keeping its shape well when ripe, flesh not more than 4 mm. thick, rather firm.

Skin mostly loose, light yellow (between saffron (VI, 4) *and maize* (VI, 21)), *blistering conspicuously* in ripe fruit; fruit about 50 mm. long, less than two-fifths as wide, oblong, often somewhat larger near the apex than elsewhere, between bay (IV, 5) and maroon (IV, 2) when ripe, its surface shiny; flesh 2.5 to 3.5 mm. thick, rather soft; seed 27 to 28 mm. long, about one-third as wide, generally somewhat curved, between fawn (III, 22) and cinnamon (III, 20) colored, the ventral channel open, the germ pore considerably above the middle, conspicuous; giant cells spherical to short elliptical (the great majority less than twice as long as wide), none angular, deep ferruginous (IV, 10) in color; branches of the fruit clusters orange.....*Kharooby* (p. 86).

Skin not conspicuously blistered, russet (III, 16) *or hazel* (IV, 12) *colored.*

Fruit 45 mm. long, 20 mm. wide, oblong, tapering slightly to the apex, *bay* (IV, 5) *to light maroon* (IV, 2) *in color when ripe*, rather shiny; *flesh 3.5 to 4 mm. thick*, rather tough; seed 27 to 30 mm. long, about one-third as wide, russet (III, 16), its surface roughened with fine wrinkles, the ventral channel open, the germ pore below the middle; *giant cells spherical to rod-shaped, many of them 3 times as long as wide, none angular, raw sienna* (V, 2) *in color;* branches of the fruit clusters orange.....*Lagoo* (p. 80).

Fruit 45 to 50 mm. long, about two-fifths as wide, oblong, often strongly curved, *very dark prune purple* (VIII, 1) with a conspicuous bloom *when ripe;* skin rather tough, *not shiny; flesh 2 mm. thick;* seed 25 to 30 mm. long, about one-third as wide, russet (III, 16), often curved, the ventral channel narrow, open; *giant cells sometimes angular or pointed, the majority spherical, few more than one and one-half times as long as wide, orange ochraceous* (V, 3) *in color;* branches of the fruit clusters deep orange. *Gasby* (p. 87).

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[a] Description supplemented from fruit from Tempe, Ariz., garden, borne by 2 palms originally from Biskra, Algeria.

INTERMEDIATE SOFT DATES.

Obovate Intermediate Soft Dates.

Fruit 42.5 to 45 mm. long, square at base, rounded at apex, bright orange before maturity, *becoming very dark (almost black) brown purple when ripe;* flesh about 3 mm. thick, very dark colored and very soft, fruit keeping its shape poorly when ripe; seed 20 to 24 mm. long, two-fifths to one-half as wide, rounded at both ends, the ventral channel rather wide, open; *giant cells extremely variable in shape and size, mostly sharp angled and even pointed, triangular or quadrangular in outline,* orange rufous (IV, 13) in color; branches of the fruit clusters deep orange.
Bent Segny (p. 87).

Fruit maroon (IV, 2) *or bay* (IV, 5) *when ripe; giant cells fairly uniform in shape and size, not pointed or triangular.*

Fruit 40 to 42.5 mm. long, tapering slightly at both ends, extremely soft, *not keeping its shape when preserved,* bright bay (IV, 5) when ripe, skin where loose saffron colored (VI, 4); flesh about 3 mm. thick, translucent, light colored; seed 24 to 26 mm. long, about one-third as wide, the ventral channel open; *giant cells all rounded,* mostly spherical but a few elliptical, none more than twice as long as wide, mostly much smaller than in Bent Segny, orange rufous (IV, 13) in color___*Deglet Hassen* (p. 92).

Fruit not exceeding 40 mm. long, moderately soft, keeping its shape fairly well when preserved; giant cells many of them angular.

Fruit very dark colored (between prune purple (VIII, 1) *and brown) when ripe,* 30 to 38 mm. long, generally obovate or obovate oblong, square at base, rounded at apex; skin where loose burnt umber (III, 8) color; flesh 2 to 3 mm. thick, very soft and dark colored; fibrous lining of the central cavity well developed; seed about two-thirds as long as the fruit, about two-fifths as wide as long, blunt at both ends, mars brown (III, 13) in color, the ventral channel open, the germ pore very indistinct; *giant cells chiefly spherical or short elliptical* but many quadrangular with rounded angles, *few of them more than one and one-half times as long as wide,* tawny (V, 1) in color; branches of the fruit clusters orange (VI, 3)_____*Ammary*[a] (p. 88).

Fruit bay (IV, 5) *or maroon* (IV, 2) *when ripe; giant cells all or nearly all angular, mostly not longer than wide, almost never more than one and one-half times as long as wide.*

Fruit about 40 mm. long; seed averaging 25 mm. long, about one-third as wide, *the ventral channel wide, open, the germ pore near the base;* flesh about 3 mm. thick; *giant cells mostly angular but many spherical,* the great majority not longer than wide ($\frac{1}{3}$ to $\frac{1}{2}$ as large as in Deglet Hassen), orange ochraceous (V, 3) in color; branches of the fruit clusters bright *orange*_____ *Goondy* (p. 88).

Fruit 35 to 37.5 mm. long; flesh about 3 mm. thick; *seed averaging 20 mm. long,* about two-fifths as wide, *the ventral channel, narrow but open; giant cells all more or less angular,* (about twice as large as in Goondy), ochraceous (V, 7) in color; branches of the fruit clusters orange_____ *Zekry* (p. 81).

Ovate Intermediate Soft Dates.

*Firm white central portion of the flesh at least twice as thick as the soft, dark-colored outer portion*_____*Kenta.*[b]

Firm white central portion of the flesh not nearly so thick as the soft, dark-colored outer portion.

White fibrous lining of the central cavity little developed; fruit 35 to 50 mm. long, narrowed from about the middle to the rounded apex and often

[a] Description drawn up from material from Tempe, Ariz., garden, from a palm originally from Ourlana, Algeria.

[b] This variety (as well as the Angoo, p. 97) belongs evidently to the dry date class, and is described on p. 97; but, on account of its smooth, very loose skin (narrow transverse wrinkles few or none), it is likely to be sought in this part of the key.

also to the base, orange rufous (IV, 13) before maturity, maroon (IV, 2) when ripe, its skin ochraceous (V, 7) colored where loose, shiny; flesh soft, 4 to 6 mm. thick; *seed* a little more than half as long as the fruit, *generally conspicuously pointed at the apex and often narrowed to the base, very smooth, chestnut* (IV, 9) *colored;* the ventral channel more or less closed; giant cells mostly rounded (a few with rounded angles) either spherical or short elliptical (1 to 2 times as long as wide), rufous (IV, 7) colored, branches of the fruit clusters maize (VI, 21) yellow.

Deglet Noor (p. 63).

White fibrous lining strongly developed throughout the length of the central cavity; seed generally rounded at both ends, rough, light colored (*cinnamon* (III, 20) *to Isabella* (III, 23) *brown*).

Ripe fruit dark prune purple, its skin adhering closely to the flesh, (*very little blistered or wrinkled*), *conspicuously marked with transverse and longitudinal linear scars;* fruit 40 to 45 mm. long, narrowed from about the middle to the rounded apex, keeping its shape perfectly when ripe; flesh about 4 mm. thick, firm but tender; seed 22 to 23 mm. long, nearly one-half as wide, widest near the middle, rounded at the ends, the ventral channel closed; giant cells very small, the majority angular (generally somewhat regularly quadrangular), but many spherical or pear-shaped, rarely more than one and one-half times as long as wide, orange rufous (IV, 13) colored; branches of the fruit clusters bright orange.

Khalt Mooashem (p. 81).

Ripe fruit not darker in color than purplish maroon (IV, 2), *much of the skin blistered, not scarred.*

Branches of the fruit clusters maize yellow (VI, 21); *fruit 40 to 42.5 mm. long,* narrowed from about the middle to the rounded apex, *between maroon* (IV, 2) *and prune purple* (VIII, 1) *when ripe,* with considerable bloom; skin where loose tawny ochraceous (V, 4), somewhat shiny; flesh about 4 mm. thick; seed about two-fifths as long as the fruit, about one-third as wide as long, cinnamon brown (III, 20), the ventral channel open, the germ pore above the middle; *giant cells* very uniform in shape and size, *nearly all rounded and spherical,* ferruginous (IV, 10) *in color*----------*Khalt Deglaowia* (p. 82).

Branches of the fruit clusters orange (VI, 3), *fruit 45 to 50 mm. long or, if shorter, the ripe fruit bay colored* (IV, 5) *and the giant cells mostly sharp-angled.*

Fruit 40 mm. long, narrowed from near the base to the rounded apex, dull orange before maturity, *bay colored* (IV, 5) *when ripe,* skin where loose tawny olive (III, 17), somewhat shiny; *flesh about 3 mm. thick,* rather tough; seed 23 to 25 mm. long, about one-third as wide, the ventral channel open; *giant cells* very diverse in shape and size, *the great majority sharp-angled* (very few spherical), and irregularly triangular or quadrangular in outline, sometimes irregularly club-shaped or cigar-shaped, often sharp-pointed or even aristate, more than half of them 2 to 3 times as long as wide, orange (VI, 3) to orange rufous (IV, 13) in color----------*Karoop* (p. 89).

Fruit 45 to 50 mm. long; giant cells all rounded or, if sharp-angled, the color of the fruit dark (*between maroon* (IV, 2) *and prune purple* (VIII, 1) *and the flesh 4 to 6 mm. thick.*

Flesh only 3 mm. thick, translucent, soft, *sugar not crystallizing on the cut surface; fruit 50 mm. long,* tapering from at or near the base to the somewhat pointed apex, *light orange before maturity, bright bay* (IV, 5) *when ripe;* skin where loose ochraceous (V, 7), shiny; seed about one-half as long as the fruit, about two-fifths as wide as long, deeply furrowed at base, the ventral channel open; giant cells all rounded (or a few very indistinctly angled), the majority elliptical (1½ to 2 times as long as wide), a few spherical, orange rufous (IV, 13), of nearly the same size and color as in the Deglet Noor (see above)--*Selatny* (p. 93).

Flesh 4 to 6 mm. thick, sugar crystallizing conspicuously on the cut surface; fruit 45 to 50 mm. long, dull orange red before maturity, dark maroon (IV, 2) *to prune purple* (VIII, 1) *when ripe.*

Fruit narrowed from at or near the base to the somewhat pointed apex, skin where loose tawny (V, 1); seed 25 to 26 mm. long, about one-third as wide, more or less truncate at apex, the ventral channel open or partly

closed; *giant cells very small* (resembling those of Deglet Noor and Selatny), *quite uniform in size and shape, all rounded*, spherical or short elliptical, *rarely more than one and one-half times as long as wide, rufous* (IV, 7) *in color*_____*Khalt Horraowia* (p. 82).

Fruit not conspicuously narrowed until from about the middle, broad at apex, skin where loose ochraceous (V, 7), seed 24 to 25 mm. long, about two-fifths as wide, rounded at apex, the ventral channel open or partly closed; *giant cells 3 to 4 times as large as in the preceding, extremely diverse in size and shape, all angled* (generally sharply so), irregularly triangular or quadrangular or angular rod, club, or pear shaped, *often three to four times as long as wide, between saffron* (VI, 4) *and orange* (VI, 3) *in color*_____*Khalt Menakhry*[a] (p. 93).

Oblong Intermediate Soft Dates.

Fruit nearly black when ripe, very soft, not keeping its shape well, 35 to 40 mm. long; *giant cells mostly angular*_____*Tozer Zaid Safra*[b] (p. 85).

Fruit not darker than chestnut (IV, 9) *or maroon* (IV, 2) *when ripe, or, if black, the giant cells all rounded, none angular.*

Fruit black when ripe, very soft, not keeping its shape well, 40 to 45 mm. long; seed about three-fifths as long as the fruit, about one-third as wide as long, between mummy brown (III, 10) and russet (III, 16) in color, the ventral channel open or partly closed, the germ pore above the middle; *giant cells all rounded*, spherical or short elliptical, not more than one and one-half times as long as wide, orange (VI, 3) colored.

Tenaseen[c].

Fruit brown, bay (IV, 5), *or maroon* (IV, 2) *when ripe.*

*Fruit conspicuously wider near the middle than elsewhere and rapidly diminishing in width from that point to the narrow base and apex; seed generally tapering from near the apex to a rather sharp point*_____*Deglet Noor.*[d]

Fruit only moderately wider near the middle than elsewhere and gradually diminishing from that point to the base and apex, or else of about the same width throughout almost its entire length; seed more or less rounded and abruptly tipped (mucronate) at apex, not taper pointed.

Fruit when ripe light hazel (IV, 12) *colored without any tinge of purple*, the skin where loose saffron-yellow (VI, 4), shiny, 47.5 to 50 mm. long, somewhat blunt pointed at the apex, *not keeping its shape well; flesh* about 5 mm. thick, *very soft and sirupy*, with almost no white fibrous lining to the central cavity; seed 23 to 25 mm. long, a little more than one-third as wide, russet (III, 16) to chestnut (IV, 9) colored, the ventral channel open, the germ pore below the middle; *giant cells* quite uniform in size, *mostly rounded* (spherical, short elliptical, or pear-shaped), some quadrangular with rounded angles, none more than one and one-half times as long as wide, orange rufous (IV, 13) to ferruginous (IV, 10) in color.

Deglet Hamidatoo (p. 92).

Fruit when ripe darker colored, bay (IV, 5), *maroon* (IV, 2), *or chestnut* (IV, 9), *with a purple tinge or, if hazel* (IV, 12) *colored and without purple tinge, then of rather firm consistency, keeping its shape well when preserved and with the giant cells mostly angular (Areshty).*

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[a] These four "Khalts" (Mooashem, Deglaowia, Horraowia, and Menakhry) have the skin more or less conspicuously transversely wrinkled as well as blistered, and the flesh, although tender, of quite firm consistency, characters belonging rather to the dry than the soft dates (see p. 96), and they appear to be somewhat related to the Horra variety (see p. 98); but on account of their thick sugary flesh and rich flavor, it seems proper to class them among the soft dates.

[b] The fruit of this variety is usually considerably less than twice as long as wide (see p. 100).

[c] This variety is common in the oases of eastern Algeria. A young palm in the garden at Tempe, Ariz., originally from Ourlana, Algeria, has much shorter, obovate fruit and although labeled "Tenaseen" it is certainly not identical with the above-described fruit, which was obtained in the Oued Souf. The latter is in all probability the true Tenaseen.

[d] This variety has the fruit generally decidedly larger near the base than near the apex and is therefore classed with the ovate intermediate soft dates. The form described on this page is the exception, that on page 104 is the rule.

Fruit when ripe chestnut colored (IV, 9) *with a very slight purple tinge*, the skin where loose tawny olive (III, 17) or ochraceous (V, 7), shiny, *the fruit* bright orange before maturity, nearly 50 mm. long, somewhat pointed and *conspicuously one-sided at apex*, not keeping its shape well when ripe; *flesh* about 4.5 mm. thick, *extremely soft and sirupy*; seed 23 to 24 mm. long, about two-fifths as wide, chestnut (IV, 9) colored; the ventral channel more or less closed, giant cells very diverse in size and shape, all angled (often sharply so), generally considerably longer than wide, triangular, quadrangular, or somewhat pear-shaped, the outlines often very irregular, ferruginous (IV, 10) in color—*Iteema* (p. 89).

Fruit when ripe bay (IV, 5) *or maroon* (IV, 2) *to prune purple* (VIII, 1) (*varying to hazel* (IV, 12) *in Areshty*), *not or not conspicuously one sided at apex.*

White fibrous lining to the central cavity almost none, flesh only about 2 mm. thick, all soft and dark colored when ripe; fruit 45 mm. long, oblong, narrowed slightly at both ends, keeping its shape only fairly well when ripe, bright orange yellow before maturity, maroon (IV, 2) with slight purple tinge when ripe, *skin where loose saffron* (VI, 4) *to orange* (VI, 3), shiny; seed about three-fifths as long as the fruit and about one-third as wide as long, the ventral channel open or closed; giant cells never more and usually less than twice as long as wide, quite variable in form, nearly all angular, in outline triangular, quadrangular, or somewhat pear-shaped; color orange rufous (IV, 13) to ferruginous (IV, 10)—*Chedakh* (p. 92).

White fibrous lining to the central cavity well developed, flesh at least 3 mm. thick, skin where loose ochraceous (V, 7) *to russet* (III, 16), *rarely orange* (VI, 3).

Flesh soft and sirupy, 4 mm. thick; fruit keeping its shape only fairly well when ripe, 42.5 to 47.5 mm. long, slightly narrowed at both ends, reddish orange before maturity, between dark maroon (IV, 2) and prune purple (VIII, 1) with a conspicuous bloom when ripe, its surface shiny; seed between one-half and three-fifths as long as the fruit, usually slightly less than one-third as wide as long, widest below the middle or about equally wide throughout, the ventral channel open; *giant cells nearly all angular*, similar to those of the preceding (Chedakh); branches of the fruit clusters deep orange—*Fteemy* (p. 69).

Flesh of firm consistency, fruit keeping its shape well when ripe, broad at base or, if somewhat narrowed at base, the fruit only 40 mm. long, then the flesh only 3 mm. thick and the giant cells all rounded or nearly so.

Fruit 40 mm. long, generally slightly narrowed at both ends, bright maroon when ripe, with considerable bloom; *flesh 3 mm. thick, not very sugary; seed smooth*, 25 mm. long, about two-fifths as wide, widest above the middle, the ventral channel open, the germ pore above the middle; giant cells very uniform in size and shape, all rounded, spherical or nearly so, orange (VI, 3) in color—*Khalt Hameed* (p. 89).

Fruit 40 to 60 mm. long, broad at base, flesh 4 to 6 mm. thick, very sugary; seed rough.

Fruit 47.5 to 55 mm. long, oblong or oblong ovate, broad and rounded at base and apex, keeping its shape well when ripe, dull orange yellow before maturity, *between maroon* (IV, 2) *and chestnut* (IV, 9) *or between chestnut and hazel* (IV, 12) *colored* with a purplish bloom *when ripe*; flesh 4 to 6 mm. thick, the white fibrous lining to the central cavity well-developed; *seed* 23 to 25 mm. long, two-fifths to one-half as wide, russet (III, 16) to chestnut (IV, 9) colored, *its surface uniformly roughened with small pits and fine wrinkles*, the ventral channel frequently closed, the germ pore usually distinct, always above the middle of the seed; *giant cells quite uniform in size and shape, all rounded*, mostly spherical but some short-elliptical (1½ or nearly 2 times as long as wide), *rufous* (IV, 7) *colored; branches of the fruit clusters lemon yellow.*

Menakher (p. 61).

Fruit dull orange before maturity, light bay (IV, 5) *or light hazel* (IV, 12) *colored when ripe; seed roughened here and there with irregular ridges and furrows; giant cells very diverse in shape and size, nearly all angular, saffron* (VI, 4) *to orange* (VI, 3) *in color; branches of the fruit clusters light orange*—*Areshty*[a] (p. 71).

[a] The fruit of this variety is generally at least 4 mm. less than twice as long as wide, and it is therefore described more fully under Broad Soft Dates. (See p. 101.)

THE PHILADELPHIA MUSEUMS
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DESCRIPTION OF PLATES.

PLATE I. Frontispiece. Harvesting Deglet Noor dates from tall trees at Tozer.

PLATE II. Fig. 1.—An unirrigated tract of alkali land in the midst of Tozer oasis, with a growth of salt-loving samphire, or "pickle weed." Only water is needed to transform this spot into luxuriant date gardens, like those surrounding it. Fig. 2.—Working the soil of a date garden with the "messah," or short-handled hoe, preparatory to planting onions. Illustrates the frequent cultivation given well-cared-for date gardens; also (background), recently planted palms sheltered by tent-like coverings of date leaves.

PLATE III. Date palm (Khalt Aly Meskeen variety) showing the "straddling" of a heavy bunch of fruit to prevent the breaking of the stalks. This is a common practice in the Tunis oases and saves much fruit that would otherwise be lost.

PLATE IV. Fig. 1.—A Tronja palm with numerous offshoots (one as large as the main trunk) in unirrigated alkali land, showing the characteristic curving of the leaves. Fig. 2.—A typical male date palm, showing the characteristic heavy crown of foliage.

PLATE V. Fig. 1.—Menakher palm at Nefta, said to be 20 years old. One of the offshoots shown was imported into the United States. Fig. 2.—Older Menakher palm at El Oudiane, with two large fruiting offshoots.

PLATE VI. Fig. 1.—Deglet Noor palm, oasis of El Oudiane, showing the characteristic drooping of the long-stalked fruit clusters. Fig. 2.—Lagoo palm, showing horizontal or erect short-stalked fruit clusters. Fig. 3.—The town of Nefta, a community supported almost entirely by date culture.

PLATE VII. Fig. 1.—Full-grown Fteemy palms in a hollow, oasis of El Oudiane. Fig. 2.—A plantation of 6-year-old date palms at the edge of Nefta oasis, in land that was formerly covered with an efflorescence of salts. The varieties represented are Fteemy, Okht Fteemy, and Deglet Noor (a Fteemy palm near the center in the foreground). The arrangement of the "lands" for irrigation and a young crop of alfalfa among the palms are shown.

PLATE VIII. Dates, natural size. (1) Deglet Noor variety; (2) Menakher variety.

PLATE IX. Dates, natural size. (1) Tronja variety; (2) Boo Affar variety.

PLATE X. Dates, natural size. (1) Horra variety; (2) Kenta variety; (3) Fteemy variety; (4) Mokh Begry variety.

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FIG. 1.—ALKALI LAND IN THE MIDST OF TOZER OASIS.

FIG. 2.—WORKING THE SOIL OF A DATE GARDEN WITH THE "MESSAH", OR SHORT-HANDLED HOE.

DATE PALM, SHOWING "STRADDLING" OF FRUIT CLUSTER TO PREVENT THE BREAKING OF THE STALK.

FIG. 1.—TRONJA PALM SHOWING CHARACTERISTIC DROOPING, CURVED LEAVES.

FIG. 2.—A TYPICAL MALE DATE PALM SHOWING NUMEROUS LEAVES.

FIG. 1.—MENAKHER PALM WITH NUMEROUS SMALL SUCKERS.

FIG. 2.—OLD MENAKHER PALM WITH TWO LARGE FRUITING SUCKERS.

FIG. 1.—DEGLET NOOR PALM.

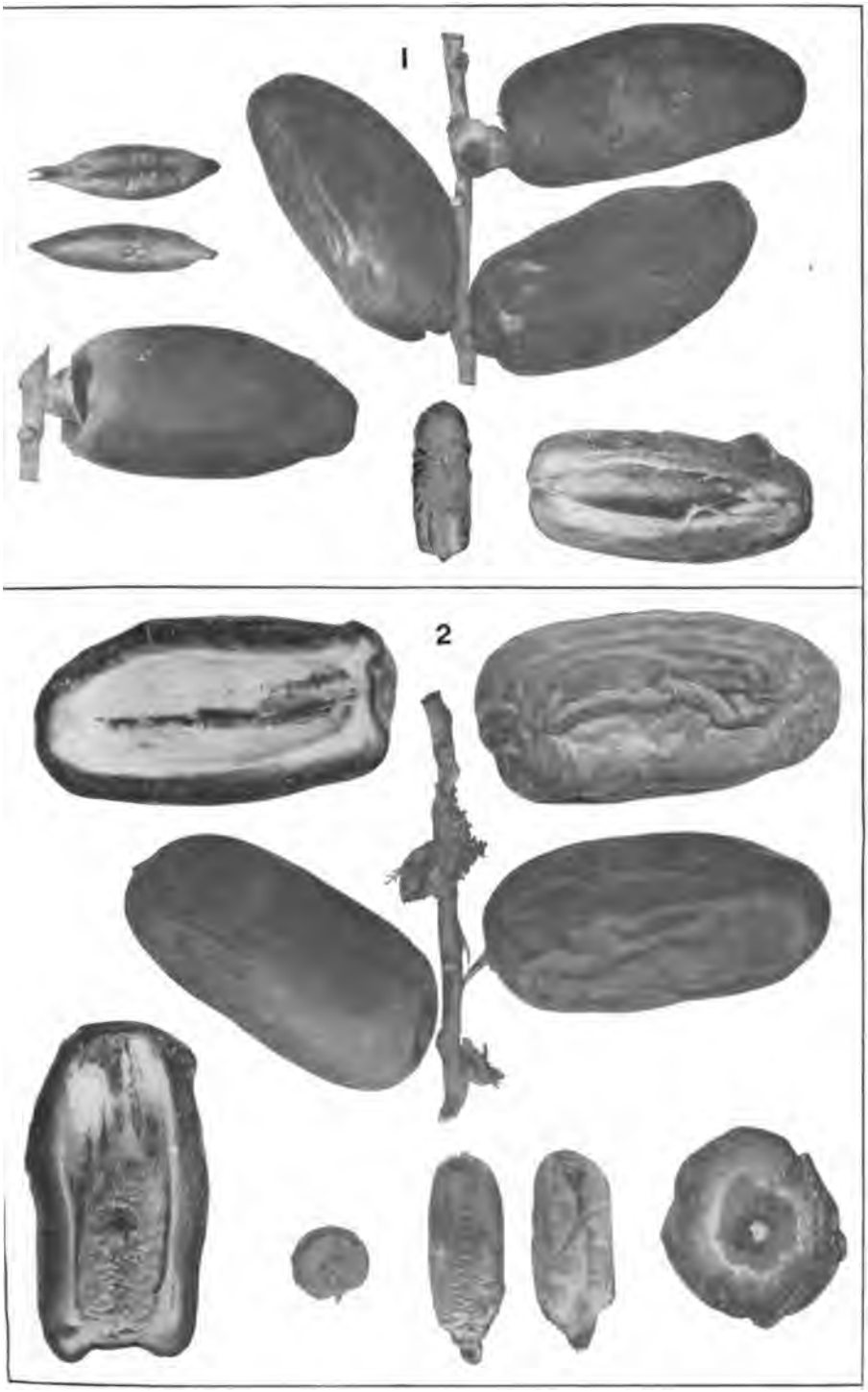
FIG. 2.—LAGOO PALM.

FIG. 3.—THE TOWN OF NEFTA, WITH DATE GARDEN IN LEFT FOREGROUND.

FIG. 1.—FTEEMY PALMS, EL OUDIANE.

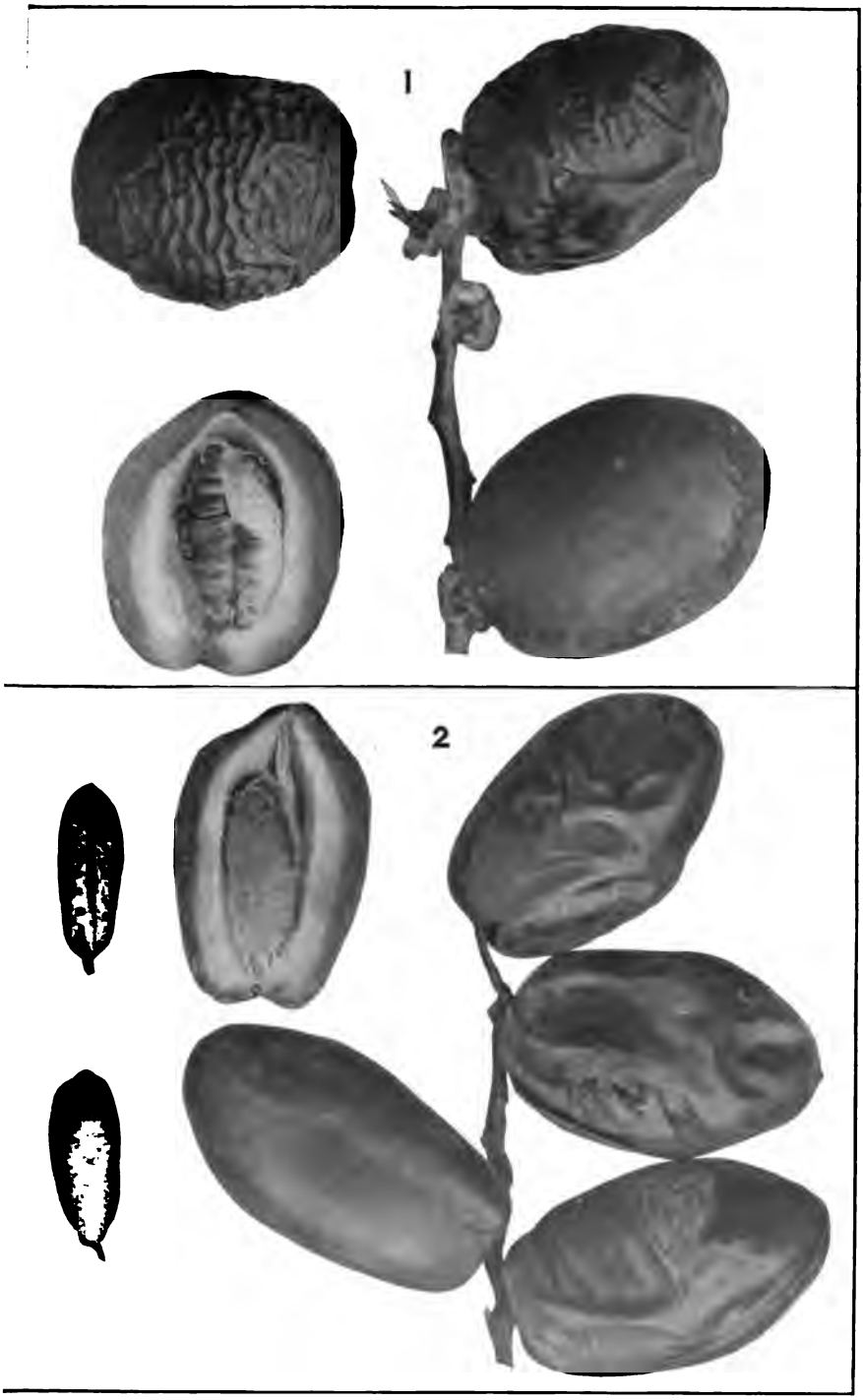
FIG. 2.—PLANTATION OF SIX-YEAR-OLD DATE PALMS AT NEFTA.

A Fteemy palm in the foreground.



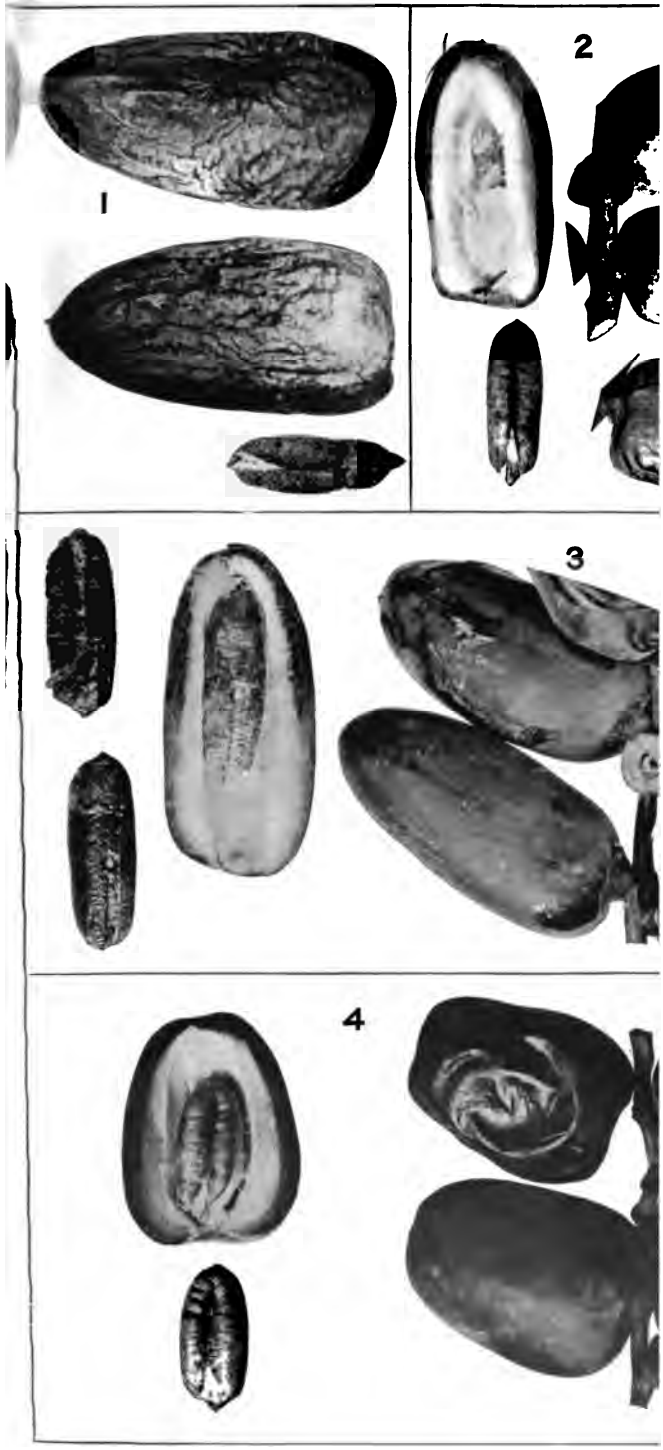
DATES, NATURAL SIZE.

1.—Deglet Noor variety. 2.—Menakher variety.



DATES, NATURAL SIZE.

1.—Tronja variety. 2.—Boo Affar variety.



DATES, NATURAL SIZE.

1.—Horra variety. 2.—Kenta variety. 3.—Fteemy variety.

APPLES BADLY AFFECTED WITH BITTER-ROT ON THE SAME TWIG WITH MUMMIES OF THE PRECEDING YEAR'S CROP.

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U. S. DEPARTMENT OF AGRIC

BUREAU OF PLANT INDUSTRY—BULLETIN

B. T. GALLOWAY, *Chief of Bureau.*

THE

CONTROL OF APPLE BI

BY

W. M. SCOTT, PATHOLOGIST

VEGETABLE PATHOLOGICAL AND PHYS
INVESTIGATIONS.

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B. T. GALLOWAY,
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W. W. COBEY, *Tobacco Expert.*
JOHN O. MERWIN, *Scientific Assistant.*

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[a] Detailed to Bureau of Chemistry.
[b] Detailed from Bureau of Chemistry.

LETTER OF TRANSMITTAI

U. S. DEPARTMENT OF AGRICULT
BUREAU OF PLANT I
OFFICE O
Washington, D. C.,

SIR: I have the honor to transmit herewith t bulletin entitled "The Control of Apple Bitter-I Scott. This paper was submitted by Mr. A. F. and Physiologist of the Bureau, with a view to pu

This Bureau has for a number of years been inve disease, which nearly every year causes great lo The loss some years has been estimated to be mo Although many attempts have been made to conti ordinary spraying methods, the results have beer Scott has discovered the reason for these failure his investigations during the present season (wh ingly favorable for the development of bitter-r disease can be successfully controlled at a nominal c through demonstration experiments to be condu apple districts, to bring the method into general

I respectfully recommend that this paper be p No. 93 of the series of this Bureau.

The accompanying illustrations are essential to a of the text.

Respectfully, B. T

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE CONTROL OF APPLE BITTER-ROT.

INTRODUCTION.

Accounts of severe losses of the apple crop of the United States caused by bitter-rot (*Glomerella rufomaculans* (Berk.) Spaulding & von Schrenk) date back to 1870, and since that time destructive outbreaks of this disease have occurred at frequent intervals with apparently increasing severity until a loss of several million dollars in a single season is not uncommon. An epidemic occurred in 1900, when it was estimated that the damage to the apple crop of the United States was $10,000,000,[a] and in 1902 the attacks of the fungus were again exceedingly severe.

Although the fungus causing this disease occurs in nearly every apple-growing State in the eastern part of the United States, severe losses from it have been confined to the southern half of the apple belt, Missouri, Illinois, Arkansas, Virginia, West Virginia, and Kentucky suffering especially in recent years.

This disease has had the attention of the Department of Agriculture for a number of years. In the Report of the Chief of the Section of Vegetable Pathology for 1887[b] appeared the first economic discussion of the disease by an American writer, followed in 1891[c] by a more extensive account of the fungus by Miss E. A. Southworth. In 1903 Messrs. von Schrenk and Spaulding,[d] of the Mississippi Valley Laboratory of the Bureau, published a general account of the bitter-rot disease with a description and life history of the fungus causing it.

In 1903 the attention of the Bureau of Plant Industry was called to an outbreak in Virginia and West Virginia, and the writer was detailed to investigate the trouble and arrange for remedial experiments. During the months of August and September (1903) a number of orchards in each of these States were visited, and it was found that, although several other good varieties were affected, the highly prized Yellow Newtown (also known as Albemarle Pippin) was, as usual, the greatest sufferer. In some cases the destruction was complete, and to

[a] Woods, A. F. Annual Reports, Department of Agriculture, 1901, p. 47.

[b] Annual Report of the Commissioner of Agriculture, 1887, pp. 348–350, Pl. III.

[c] Journal of Mycology, VI, pp. 164–173, Pl. XVI.

[d] Bul. 44, Bureau of Plant Industry, U. S. Department of Agriculture, 1903.

find as much as 50 per cent of the fruit of this variety harvested in good condition was exceptional. The Yellow Newtown growers of this section had had a similar experience with the crops of 1901 and 1899 (two and four years previous), and some were on the point of abandoning their orchards in despair, one man going so far as to cut down his trees. It seemed, therefore, especially desirable for the Bureau to determine the best methods for combating this disease and to obtain data upon which definite recommendations could be based. Accordingly a series of experiments was planned, which were carried out in the orchards of Mr. W. H. Goodwin, at Avon, Va., to whom the Department is much indebted for valuable services in facilitating the work. The work was outlined and some spraying done in the spring of 1904, but this being the "off year" it soon developed that there would be no crop of apples in that section, and the actual work reported upon in this paper was not commenced until the spring of 1905.

THE DISEASE AND ITS CAUSE.

A detailed account of the disease and the fungus causing it having appeared in a previous bulletin of this Bureau,[a] many details will be omitted in the following discussion, the attempt being made to include only those facts with special bearing on the subject of this paper.

THE DISEASED SPOTS ON THE APPLE.

The diseased spots are usually a quarter to a half inch in diameter before the fruit grower ordinarily notices them, but they first appear as very small, yellowish-brown, sometimes watery specks, frequently bordered with a ring of purple-red. The purplish margin is especially prominent on spots that are retarded by cool weather, and many late infections appear only as red or purplish specks, never developing farther on account of adverse conditions. On the other hand, the purplish coloration is likely to be entirely absent from a spot that is developing rapidly under favorable conditions. As the spot enlarges and grows older it becomes dark-brown in the center, shading off into a light watery margin. It is circular in outline, with a well-defined margin, and soon becomes sunken. (See Pl. I, and Pl. VI, fig. 1.)

When the spots are about one-half inch in diameter, fruiting pustules begin to appear in the form of small black dots slightly raised and usually arranged in concentric rings (Pl. VI, fig. 1). These pustules soon break through the skin (Pl. II, *6*), discharging pink, sticky spore masses, which are readily washed off by dews and rains. As the disease progresses, other rings of pustules appear and give forth spores in great abundance. When the pink spore masses are washed away the pustules appear as black ragged openings through the skin of

[a] Von Schrenk and Spaulding, l. c.

the apple. An apple may have only one diseased spot, but in a serious outbreak there are usually several, and it is not uncommon to see a fruit literally peppered with points of infection. During the past season the writer counted 1,200 on a single apple and estimated 1,000 on each of several others. When so numerous, these spots are at first raised, appearing as small brown blisters on the skin of the apple, and are frequently so arranged as to suggest that the points of infection had followed drops of water trickling down the sides of the apple, the specks being distributed evenly over the upper or stem end, from which the specked areas extend in strips toward the calyx end.

When a number of spots appear on a single apple, they soon coalesce, and three or four, gaining the ascendency, envelop the others and retain their circular shape, each producing its rings of fruiting pustules. Finally the entire fruit is converted into a dark-brown, shriveled, and wrinkled mummy, which may hang on the tree a year or more. (Pl. I, and Pl. VI, fig. 1.) However, the majority of the affected fruits fall to the ground before they are half rotten, and their decomposition is hastened by scavenger insects and decay fungi.

THE BITTER-ROT FUNGUS.

The bitter-rot disease is due to a fungus which has received the botanical name *Glomerella rufomaculans* (Berk.) Spaulding & von Schrenk,[a] but which has been known until recently as *Gloeosporium fructigenum* Berk.[b]

This microscopic plant, developing from a spore that has found its way to the apple, penetrates the skin in the form of a minute tube, which immediately begins to branch and grow rapidly in every direction. This mycelium absorbs its nourishment from the cells of the apple, killing them and thus producing the brown sunken spots known as bitter-rot.

The mycelium.—The diseased tissue is filled in the intercellular spaces with pale, delicate, much-branched threads of mycelium, which are septate, slightly granular, and chiefly 4 to 6 μ in diameter. (Pl. II, *4*, *a*.) Under favorable conditions the mycelium grows very rapidly, killing the fruit cells almost as fast as it enters the healthy tissue. It grows toward the center of the apple at a rate about equal to its lateral progress. After a time these threads become congregated just beneath the surface at certain points almost equidistant from the point of infection, forming stromata, which give rise to upright bundles of interwoven branches. These are the spore-bearing hyphæ,

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[a] Von Schrenk and Spaulding. The Bitter-Rot of Apples, Bul. 44, Bureau of Plant Industry, U. S. Dept. of Agriculture, p. 29. Saccardo (Annales Mycologici, 2, p. 198) thinks the name should be *Glomerella fructigena* (Clinton) Sacc.

[b] Berkeley, M. J. *Gloeosporium fructigenum*, n. s., Gardeners' Chronicle, 1856, p. 245.

which rupture the skin and give forth pink masses of conidia, or summer spores. (See Pl. II, *6*.)

Summer spores.—It is thought to be chiefly by means of summer spores that this fungus is propagated and disseminated, and countless millions of them may be produced from one rotton spot. They are produced one after another by abstriction from the ends of the fruiting branches of the fungus, and, as previously explained, exude through the ruptured skin of the apple in pink, sticky masses easily visible to the naked eye. They are readily washed off by the action of dew and rain, but upon drying become hard and glued to the skin of the apple.

A microscopic examination shows these spores to be oblong, almost cylindrical, one-celled bodies with a delicate pale-green color and granular contents. They vary in size, as also in shape, but normally measure $4–5 \times 10–15\ \mu$. (Pl. II, *4*, *a*.)

Ascospores.—In addition to the conidia, or summer spores, which are produced so rapidly and in such great numbers, another type of spore is produced on the old rotten apples in the autumn and probably also the following spring. These ascospores, measuring about $5 \times 20\ \mu$ (Pl. II, *2*), are scarcely distinguishable from the summer spores, but are usually slightly curved and are borne in little sacs containing 8 spores each. These sacs, or asci (Pl. II, *1*), are produced inside of little brownish spore cases (perithecia) embedded in black nodules of mycelium on the surface of the rotten apple or mummy. This constitutes the mature stage of the bitter-rot fungus as first discovered by Clinton,[a] and is probably a means of carrying the fungus over winter and starting infection the following spring. Von Schrenk and Spaulding[b] found it on limb cankers as well as in artificial cultures. The writer secured this stage of the fungus on a number of artificially infected apples in the laboratory about three weeks after inoculation, and it developed on a few rotten apples brought in from the orchard and placed in a moist chamber. It also developed abundantly in artificial cultures on sterilized potato and nutrient agar within six weeks after inoculation.

Germination of the spores.—Placed in a drop of water under a microscope, both conidia and ascospores may be seen to germinate within three or four hours, each spore throwing out one or two, sometimes three, germ tubes. (Pl. II, *3* and *5*.) During germination a cross septum usually develops in the center of the spore, which soon becomes emptied of its contents. These germ tubes grow very rapidly, reaching several times the length of the spore within an hour after germination, and then begin branching.

There is some question as to how the threads from the germinating

[a] Clinton, G. P. Apple Rots in Illinois, Bul. 69, Ill. Agr. Exp. Sta., 1902, pp. 206–211, Pl. J.

[b] Bul. 44, Bureau of Plant Industry, U. S. Department of Agriculture, 1903.

spore find their way through the skin of the apple. The most common belief expressed by writers upon this subject is that the fungus enters through insect punctures or some other abrasion of the skin, and it has also been suggested that the fungus could probably enter through the unbroken skin. The writer's observations would indicate that a wound is not at all necessary for successful infection and that the fungus most commonly penetrates the skin. Several hundred points of infection were examined without finding any indication of a previous puncture. A large percentage of the apples on the untreated trees used as checks in the spraying experiment had from one hundred to a thousand points of infection, and in many cases the spots were so thick that when only one-sixteenth of an inch in diameter they overlapped. In the laboratory, infections were easily made by dropping water containing spores on the unbroken skin of an apple in a moist chamber.

BITTER-ROT CANKERS ON THE BRANCHES.

In 1902 it was discovered by Mr. R. H. Simpson, of Illinois, that limb cankers were associated with outbreaks of bitter-rot. Messrs. Burrill and Blair[a], of the Illinois Agricultural Experiment Station, and Messrs. von Schrenk and Spaulding[b], of the Mississippi Valley Laboratory of the Bureau of Plant Industry, working independently, soon established the relationship of these cankers to the disease on the fruit and proved by inoculation tests that these cankers were caused by the same fungus that attacks the fruit.

In describing this form, von Schrenk and Spaulding[c] state that "The cankers found on apple trees in Illinois appear as blackened depressions on apple limbs of various sizes, from last year's fruit spurs to limbs 3 to 4 inches in diameter. Thus far the cankers have not been found on the main trunk. On these limbs rounded or oblong sooty-black sunken spots occur from one to several inches long, which have more or less ragged edges." Limb cankers occur abundantly in the Virginia orchards, but the writer has so far been unable to find the bitter-rot fungus associated with any of them. However, limbs of young apple trees on the grounds of the United States Department of Agriculture inoculated with bitter-rot spores rapidly developed these cankers.

SOURCE OF INFECTION AND SPREAD OF THE DISEASE.

The question as to the chief source of the first infection each year has not been satisfactorily settled, nor is it definitely known how the

[a] Circ. 58, Ill. Agr. Exp. Sta., July, 1902, and Bul. 77, Ill. Agr. Exp. Sta., 1902, pp. 355–357.

[b] Bul. 44, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1903, pp. 29–36.

[c] L. c., p. 31.

fungus is spread from tree to tree and from orchard to orchard. It seems, however, that the mummied fruit and the limb cankers are both instrumental in carrying the fungus over winter and starting the annual infection, and that insects play an important rôle in the spread of the spores.

During the season of 1903 and again in 1905 the writer visited a number of infected orchards in Virginia and West Virginia, making special observations upon this problem. The results lead to the conclusion that the overwintering mummies hanging on the trees constitute the chief source of infection, at least in this particular region. In the majority of cases examined a mummy could be found in the upper portion of the infected area, but in no case was there found associated with such outbreaks any cankers that could be identified as bitter-rot cankers. However, from observations made in the Middle West, Burrill and Blair[a] and von Schrenk and Spaulding[b] conclude that the canker is the chief source of early infection, the fungus being held over winter in the diseased limbs and producing spores for the infection of the new crop of apples. Hasselbring[c] demonstrated that the fungus of bitter-rot remains alive over winter in the mummied apples. It seems possible that the mature spore form of the fungus discovered by Clinton may develop the following spring in the mummied fruits, starting the infection on the new crop.

After one apple on a tree becomes diseased and begins to produce spores, further infections may readily take place through the medium of raindrops which splash the spores to adjacent fruits, and heavy dews may wash the spores to the apples below. Insects are also undoubtedly instrumental in disseminating the disease,[d] and they are possibly the chief carriers of the spores from tree to tree. On the other hand the rapidity with which the disease frequently spreads over an orchard, practically destroying the entire crop within a few days, suggests the idea that the spores are carried on the wind, and indeed they seem to be omnipresent in the bitter-rot districts, only awaiting suitable weather conditions. But the spore masses being sticky when wet and glued to the skin of the apple when dry, there seems to be little or no chance for the wind to carry the spores.

INFLUENCING CONDITIONS.

WEATHER.

The predominating conditions that influence the development of bitter-rot are temperature and humidity. A few days of hot showery

[a] Bul. 77, Ill. Agr. Exp. Sta., p. 356. 1902.

[b] Bul. 44, Bureau of Plant Industry, U. S. Department of Agriculture, 1903, pp. 36–38.

[c] Burrill and Blair, l. c., p. 354.

[d] Clinton, G. C., Bul. 69, Ill. Agr. Exp. Sta., p. 197.

weather may start an epidemic that will destroy the entire crop of certain varieties, provided the fungus is present.

Moisture.—Moisture is not only necessary for the germination of the spores, but it favors the growth of the fungus and hastens spore production. In a moist atmosphere the spores are produced much more rapidly than when the air is dry. Moreover, rain is an active agent in the spread of the disease, splashing the spores from an affected apple to adjacent healthy fruits. Heavy dews followed by hot cloudy days with a humid atmosphere appear to make ideal conditions for the rapid development of this disease.

Temperature.—The fungus causing this disease is decidedly a hot-weather fungus and rarely is a serious pest north of latitude 40° N. July, August, and September are the three bitter-rot months, and a maximum temperature near 90° F. for several days in succession, coupled with suitable moisture conditions, is necessary to start a serious outbreak. Infection of some fruits may take place as early as the middle of June,[a] but the fungus grows slowly and fruits sparingly until the warmer weather of July increases its rate of development. In Virginia, on July 10, 1905, the writer observed bitter-rot spots covering a quarter to half of the apple. One specimen was somewhat more than half involved in rot, and the numerous rings of spore masses indicated that the fungus had been fruiting abundantly for days, and the infection had doubtless taken place a couple of weeks earlier. The variety was Yellow Newtown, and the fruit was scarcely more than half grown. The proper combination of heat, moisture, and an abundance of spores may not occur until August or September, or in some seasons not at all.

The fungus is so influenced by the heat of the sun, and perhaps by the light also, that the fruit on the south side of a tree may become badly affected before the disease is noticeable on the opposite side. Stinson[b] observed this fact, and in the Virginia orchards the writer found that almost invariably the fruit on the sunny side was destroyed first, and oftentimes a portion of the crop on the north side would escape when the destruction was complete on the south side. This held true not only in the particular orchard under experimentation, but in many orchards visited during the outbreak of 1903, and during the past season as well. Moreover, it was observed that fruit on the inside lower branches well protected from the sun was less attacked and often escaped when that on exposed portions of the same tree was destroyed. Owing perhaps to exposure to the sun there was a considerably higher percentage of rotten fruit on trees partly defoliated with leaf-spot fungi than in the case of trees with full foliage. Not only is the fruit on the sunny side of the tree worse affected, but the

[a] See Burrill and Blair, Bul. 77, Ill. Agr. Exp. Sta., p. 332.

[b] Bul. 1, Missouri State Fruit Experiment Station, p. 6.

points of infection are more commonly located on the sunny side of the apple. Although infections were frequently found on the shaded side of the apple, in the majority of cases, according to the writer's observations during the past season, the rotten spots developed on the side exposed to the sun.

Cold is decidedly unfavorable to the fungus and it rarely does any damage during a cool season. An outbreak may be almost completely checked by a few days of cool weather, especially when the mean temperature remains below 70° F. Late infections that take place with the approach of cool fall weather usually remain as a brown speck encircled with a red or purplish ring. However, the fungus grows somewhat in the average fall weather, and if the temperature runs up to summer heat the picked fruit may rot considerably in piles or in barrels in the orchard. This emphasizes the desirability of rushing the fruit to cold storage or to market as soon as picked. In storage at a temperature of 35° F. the fungus does not grow, and spots previously started by inoculation develop no further after being stored at this temperature.

SUSCEPTIBILITY OF DIFFERENT VARIETIES.

There is a wide range of variation in the susceptibility of the different varieties of apples to injury from bitter-rot. In Virginia the Yellow Newtown (or Albemarle Pippin) is preeminently the most susceptible commercial variety. On the other hand, the Winesap is equally conspicuous for its resistance to the disease. When in close proximity to a badly rotting variety the Winesap may become infected, but the points of infection usually remain as mere specks, rarely growing to any size. The fungus does not seem to thrive on this variety and the production of spores is scant. The Ben Davis, although one of the most susceptible varieties in the Middle West, shows a comparatively slight tendency to rot in Virginia, rarely losing more than 25 per cent of its crop. York Imperial, the variety most extensively grown in the Valley of Virginia, is less susceptible than Ben Davis, being rarely attacked to a serious extent. The Grimes also rots very little.

From rather extensive observations made during 1903 and 1905 in Virginia and West Virginia the writer has prepared the accompanying list of varieties in the order of their susceptibility to bitter-rot. This list includes only such varieties as the writer examined in orchards where bitter-rot was found, and the data are not sufficiently extensive to be entirely reliable. Those varieties almost equally susceptible are grouped together, the first group representing those that frequently lose their entire crop, the second group those that in a bad season may be expected to lose 50 to 75 per cent of their crop, the third group those that rarely suffer more than 25 per cent loss, and the fourth

group those on which the writer has never found the disease. These groups are as follows:

1. Yellow Newtown (or Albemarle Pippin), Shackleford, Bentley, Gibbs, and Missouri.

2. Arkansas Beauty, Limbertwig, Rhode Island, York Stripe, Huntsman, Pilot, Peck, Northern Spy, Jonathan, Northwestern Greening, Fall Cheese, Stark, Green Sweet, and Nero.

3. Grimes, Ben Davis, York Imperial, Gano, Arkansas, Ivanhoe, and Winesap.

4. Coffelt, Bismarck, Pewaukee, Stuart Golden, Pryor, Salome, Scarlet Cranberry, Oliver, Roxbury, Lankford, Loy, Ralls, Crawford, Carlough, and Akin.

Mr. F. W. Faurot, of the Missouri State Fruit Experiment Station, a collaborator of the Department of Agriculture, has kindly furnished the following information relative to the susceptibility of the different varieties of apples in the State of Missouri. He has arranged the varieties in their approximate order, with the most susceptible varieties first, in four classes, which do not necessarily coincide with the four classes given above. They are as follows:

1. Willow and Huntsman.

2. Ben Davis, Gano, Ingram, Smith, Rome, York Imperial, Clayton, Nickajack, and Nixonite.

3. Lowell, Porter, and Maiden Blush.

4. Arkansas, Arkansas Black, Jonathan, Grimes, Winesap, and Gilpin.

Mr. Faurot writes concerning this list as follows:

> In some seasons, however, this third group comes next to Willow and Huntsman, for when they bitter-rot at all the whole crop usually goes, especially Lowell and Porter. The reason I put them third is because some seasons they are out of the way before bitter-rot attacks them or begins to develop with any degree of severity.
>
> The varieties given constitute about all of those that are grown commercially in south Missouri. Aside from these, however, I have observed bitter-rot on very nearly every variety of apple that I have seen growing in the State, including such varieties as the ordinary Russets, Lawver, Northern Spy, Stevenson Pippin, Baldwin, and many others that are grown only a few trees in a place. I have never seen it, however, on White Pearmain, Yellow Transparent, or Red Astrachan. This is merely my personal observation, however, and I have no doubt that it occurs on these varieties the same as on others, although I have not seen it.

REMEDIAL MEASURES.

Although bitter-rot has been known in this country as a serious apple disease for at least thirty-five years, it seems that no attempt was made to find a remedy for it until about 1888. During that year Galloway[a] planned some experiments for the control of this disease,

[a] Galloway, B. T. Sulphuret of Potassium for Bitter-Rot of the Apple. Journal of Mycology, vol. V, 1889, pp. 37-38.

which were carried out by Mr. J. W. Beach, of Batavia, Ark. Sulphuret of potassium was the fungicide used, and the results reported were somewhat encouraging. In 1889 Galloway also directed a series of experiments on the treatment of this disease in Virginia. Potassium sulphid and ammoniacal copper carbonate were used, and Mr. George G. Curtis,[a] who did the spraying, reported good results from both.

The investigations thus begun were soon followed with remedial experiments by several experiment stations workers, notably Alwood,[b] Garman,[c] Stinson,[d] and Whitten,[e] all of whom reported favorable though not entirely satisfactory results from spraying with copper compounds.

Since the severe outbreak of 1900, efforts to control this disease have been continued with renewed interest, and several papers reporting results of remedial experiments have been published. In 1901 Quaintance,[f] in writing of experiments conducted in Georgia the preceding year, stated that "the results are much in favor of four applications of Bordeaux, not only in quantity of fruit but in size and appearance, and, as developed later, in keeping quality." Some of the best results that have come to the writer's attention are those reported by Stinson in 1901.[g] One plot sprayed five times gave "59 per cent of the fruit free from bitter-rot," another sprayed four times gave "78 per cent of the fruit free from bitter-rot," while one check plot had only "1.6 per cent of the fruit free from bitter-rot" and another "14 per cent of the fruit free from bitter-rot." In 1902[h] the same writer published the results of another series of experiments showing beneficial results from spraying.

As a result of their investigation in 1902, Burrill and Blair[i] recommended a systematic search for and removal of the diseased fruits and infecting cankers or mummies, stating that "the canker and infested fruit should be removed, taking care not to distribute the infection in

[a] Curtis, George G. Treatment of Bitter-Rot of the Apple. Bul. 11, Section of Vegetable Pathology, U. S. Dept. of Agriculture, 1890, pp. 38–41.

[b] Alwood, William B. Bitter-Rot. Bul. 17, Va. Agr. Exp. Sta., 1892, pp. 61–62 and 64–65. Also Ripe-Rot, or Bitter-Rot of Apple. Bul. 40, Va. Agr. Exp. Sta., 1894, pp. 59–82.

[c] Garman, H. Bul. 44, Ky. Agr. Exp. Sta., 1893, pp. 3–24.

[d] Stinson, John T. Bitter-Rot. Bul. 26, Ark. Agr. Exp. Sta., 1894, pp. 33–34.

[e] Whitten, J. C. The Bitter-Rot. Bul. 31, Mo. Agr. Exp. Sta., 1895, pp. 3–4 and 7–15.

[f] Quaintance, A. L. Bitter-Rot of Apples. Thirteenth Annual Report, Ga. Exp. Sta., pp. 360–361 and Pl. IX.

[g] Stinson, John T. Preliminary Report on Bitter-Rot or Ripe-Rot of Apples. Bul. 1, Mo. State Fruit Exp. Sta., pp 3–21.

[h] Stinson, John T. Notes on Spraying for Bitter-Rot. Bul. 2, Mo. State Fruit Exp. Sta., pp. 3–20.

[i] Bul. 77, Ill. Agr. Exp. Sta., p. 366.

the process. This is of the utmost importance if the contagion is to be stopped." They also state that "the disease can be kept in check during the summer by repeated applications of Bordeaux mixture." In a paper read before a meeting of the Illinois State Horticultural Society, Burrill[a] reports experiments conducted in three counties of southern Illinois, showing that the disease yielded to applications of Bordeaux mixture. The results of these experiments indicate especially the importance of early spraying.

Reporting upon two years' experiments, von Schrenk and Spaulding[b] state that "to a certain extent, varying from 10 to 75 per cent, Bordeaux mixture surely does prevent the ravages of the bitter-rot." They also strongly recommend the removal of diseased fruits, mummies, and limb cankers.

THE VIRGINIA EXPERIMENTS.

The orchard of Mr. W. H. Goodwin, in which the experiments were conducted, is situated on a spur of the Blue Ridge Mountains, in Nelson County, about 5 miles south of Afton. This and the adjacent county of Albemarle have long been famous for their production of the Yellow Newtown (or Albemarle Pippin) apples, some trees of which are 100 years old and still thriving. This variety is not subject to serious injury from apple scab, nor does it suffer materially from the leaf-spot diseases, and until the advent of bitter-rot magnificent crops were secured in this section without spraying.

Mr. Goodwin's orchard has a northern exposure, with an elevation of from 1,000 feet on the lower side to about 1,250 feet at the upper side. The land is very steep, having an incline of almost forty-five degrees in some places, and an extra man with a lever is required in spraying to prevent the wagon from upsetting. The soil is dark brown, almost black, deep, and fertile, such as is known throughout that section as "pippin" soil. The stones that almost completely covered the ground have been piled up in windrows, and a deep furrow has been plowed between the tree rows in which to run the upper wheels of the spray-wagon, to avoid turning over. Above the middle of the orchard is a spring with a flow of five to eight gallons a minute, which affords an ample supply of water for spraying purposes.

The bearing orchard is composed of about 800 trees of Yellow Newtown 18 to 23 years old, 500 Winesaps 8 to 23 years old, and 200 York Imperials 8 years old. There are also a number of young trees not yet in bearing. Mr. Goodwin states that the original forest was removed and the trees planted the second year after clearing, and that, as a rule, crops of corn or tobacco were grown between the rows

[a] Burrill, T. J. Experiments in Spraying for Bitter-Rot. Trans. Ill. State Hort. Soc., 1902, 54–66.

[b] Bul. 44, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1903, pp. 38–45.

until the trees came into bearing, or about twelve to fifteen years. Then the land was usually left uncultivated. A portion of it, including the experimental block, is now in sod, having been seeded to orchard grass in 1902.

According to Mr. Goodwin, bitter-rot first appeared in this orchard to a noticeable extent in 1899, and in 1901 it did considerable damage. In 1903 the trees received three early applications of Bordeaux mixture, and on September 13 of that year the writer visited the orchard and roughly estimated the loss from bitter-rot at 40 per cent. When the crop was harvested, a few days later, Mr. Goodwin estimated the loss at about 60 per cent. Since 90 per cent of the crop was lost in some unsprayed orchards in the same neighborhood, it appeared that the treatment had some effect. In 1904 there was no crop.[a]

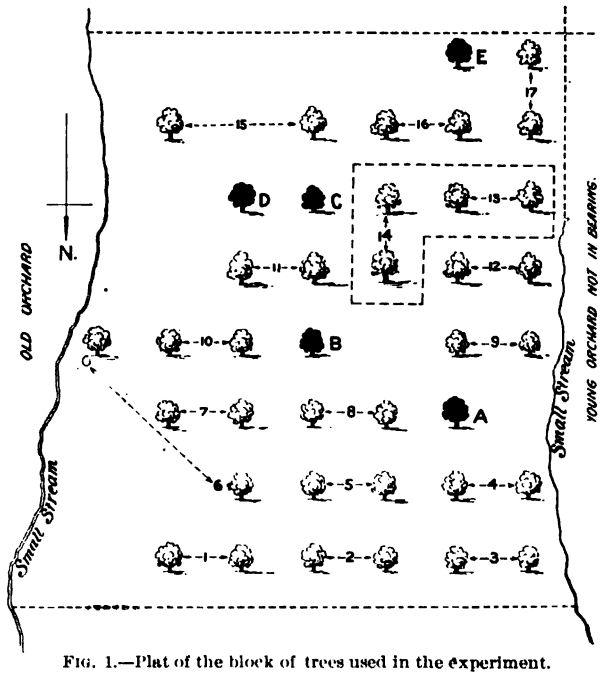

FIG. 1.—Plat of the block of trees used in the experiment.

THE EXPERIMENTAL TREES.

Only the Yellow Newtown variety was used in this experiment, the Winesap and York Imperial not being subject to serious loss from rot in this section. As may be seen from the accompanying plat (fig. 1), 35 trees were included in the experiment. They are 19 years old and about 25 feet high, with a spread of about 25 feet. These trees have been pruned by thinning out the conflicting branches, and have developed into the broad, low, somewhat pyramidal type naturally assumed by this variety. The block is situated below the middle of the orchard, with 23-year-old trees of the same variety on the east and a young orchard not yet in bearing on the west. Below (north side) is a block of young bearing trees of the same variety, the crop of which, not being properly sprayed, rotted badly. On the upper side is a block of young trees not yet in bearing.

[a] As a rule, apple trees in this section, especially the Yellow Newtown, bear only every other year.

THE PLAN OF THE EXPERIMENT.

Object.—This experiment was designed to determine (1) to what extent bitter-rot could be controlled by spraying with Bordeaux mixture, (2) the number of applications required, and (3) the proper time to make these applications. Owing to the influence of weather conditions upon this disease it was not expected that answers to all these questions could be obtained in a single season; but the season of 1905 was so favorable to bitter-rot, the disease appearing so early and continuing with such force throughout the season, that the results obtained are believed to be a safe guide for almost any season.

Spraying scheme.—In order to solve the questions just enumerated it was necessary to cover the entire season with a varying number of applications, using a process of elimination in the plan as shown in Table II (p. 23). As may be seen by reference to this table, the dates of the successive applications were as follows: April 8, May 1, May 9, June 12, June 27, July 10, July 25, August 7, August 22, and September 4. The first date was just after the cluster buds had opened, exposing the blossom buds, but before the latter had opened; the second just after the petals had fallen, and the third application eight days later. The fourth date was about six weeks after the petals had fallen, the subsequent dates being at intervals of about two weeks. The object of the first three applications was to combine the treatment of apple scab with that of bitter-rot and to determine their effect upon the latter. As shown in Table II, one group of plots (Nos. 1 to 5) receiving three to nine applications had one or more of the late sprayings omitted. From another group (Plots 9 to 12) the early applications for scab were omitted. Plots 15, 16, 17, and 12, receiving four applications each, were designed to determine the period at which spraying gives the best results. Plots 7 and 8 combine early and late spraying, leaving an early midseason interval that proved in this case to be too long. Plot 6 was sprayed just before the trees bloomed, as soon as the blossoms were shed, and eight days later (the usual apple-scab treatment), and every two weeks from June 12 to September 4, receiving ten applications in all. It was intended that Plot 9 should be sprayed at intervals of two weeks, beginning June 12, making the treatment for this plot the same as No. 6, with the three early applications omitted; but the writer inadvertently overlooked the first date. Therefore, in order to avoid duplicating No. 10, two more applications were dropped out of No. 9 later in the season. The original scheme included Plots 13 and 14, which were to have received the last three and the last two applications, respectively; but when the time arrived for their treatment to begin the crop on them was already destroyed by the rot and they were therefore dropped.

Each plot consisted of but two trees. There were, then, in the experimental block fifteen treated plots of two trees each and five

untreated trees used as checks. By referring to the plat of the block (fig. 1) it will be seen that the checks (A, B, C, D, and E) were well scattered among the sprayed trees. Plot 1, at the lower left-hand corner, practically amounted to a check, as it received only the three early applications, and 62 per cent of the crop rotted. Check A is near the lower right-hand corner and B just below the center, while C and D are near the upper left-hand corner and E at the upper right-hand corner. Other trees were originally set aside as checks, but when it was found that bitter-rot was developing abundantly on all of them some were sprayed in order to reduce the loss to the owner. Two trees to the plot might seem at first thought insufficient for determining the best results from the spraying, but the trees are quite large, yielding about 20 to 35 bushels each. Moreover, the plots are almost in duplicate, there being a difference usually of only one application in adjacent plots.

WEATHER CONDITIONS ATTENDING THE EXPERIMENT.

Better conditions for a severe test of spraying could scarcely be desired. As will be seen from the following weather table[a], there was an abundance of rain throughout the season and considerable high temperature. Beginning June 16 it rained every day except one until June 25, and during that period the temperature ranged high, reaching 89° F. on the 18th, 94° F. on the 19th, 90° F. on the 20th, 89° F. on the 21st, and 92° F. on the 22d. This combination of moisture and heat made an ideal infection period. The conditions during July were also favorable to bitter-rot. It rained every day during the first week and continued at intervals throughout the month. The temperature reached 94° F. on July 18, and was 92° F. on the preceding and the following day. The orchard was frequently enveloped in fog and the dews were usually very heavy. As a consequence all unsprayed trees showed bitter-rot early in the month, and by the end of the month the disease was well under way. This ideal bitter-rot weather continued through August, and before the end of that month the crop on all unsprayed trees was practically destroyed. The crops in the unsprayed orchards in the neighborhood were also badly affected, showing that the outbreak of bitter-rot was general in that region.

[a] No exact meteorological data being available for the immediate vicinity in which the experiments were conducted, data are given for Charlottesville, Va., the nearest point where permanent records are kept, a distance of about 25 miles from the site of the orchard used for the experiment. The weather conditions appeared to be similar in the two sections, and the table may be considered fairly representative of the conditions that prevailed in the orchard. The data are from the monthly reports of the Virginia Section of the Climate and Crop Service of the Weather Bureau.

TABLE I.—*Daily maximum and minimum temperatures and precipitation at Charlottesville, Va., for June, July, and August, 1905.*

Day of month.	June.			July.			August.		
	Temperature.		Precipitation.	Temperature.		Precipitation.	Temperature.		Precipitation.
	Maximum.	Minimum.		Maximum.	Minimum.		Maximum.	Minimum.	
	° F.	° F.	Inches.	° F.	° F.	Inches.	° F.	° F.	Inches.
1	68	52	0.03	72	64	0.48	80	61	.....
2	79	52	.04	87	63	.30	84	62	.....
3	75	54	.....	87	65	.05	84	64	.....
4	81	55	.....	89	66	2.70	88	.....	0.02
5	89	67	.....	82	66	.12	85	63	.....
6	92	71	.....	85	67	.33	91	67	.....
7	80	60	1.69	85	64	.62	90	64	.75
8	71	60	.....	87	70	.....	76	66	.02
9	77	53	.....	87	66	.....	84	67	1.67
10	81	54	.....	87	68	.....	85	69	.53
11	83	63	Trace.	85	69	.19	87	68	.11
12	86	69	.....	84	67	.82	88	71	.07
13	87	65	.....	77	68	.16	89	67	.01
14	86	65	.....	87	65	.63	82	66	.14
15	85	69	.....	89	65	.....	87	69	1.06
16	85	69	.18	87	68	.....	85	69	.....
17	86	69	.01	92	72	.....	70	59	.....
18	89	70	.05	94	74	.....	76	58	.....
19	94	67	.62	92	73	.....	75	58	.....
20	90	67	2.22	89	69	.70	82	59	.....
21	89	66	.70	85	70	.27	87	65	.....
22	92	69	.....	77	64	2.64	89	66	.....
23	83	69	.82	.....	.....	.01	88	66	.....
24	76	65	1.60	86	62	.....	88	63	.86
25	84	62	.04	80	63	.....	77	64	.36
26	87	68	.....	81	62	.....	77	63	.07
27	74	61	.....	81	61	.....	74	59	.....
28	88	57	.....	74	64	.09	77	50	.....
29	80	58	.....	85	64	.03	87	56	.....
30	82	62	.....	84	61	.....	89	70	.....
31	.....	.....	.....	77	65	.....	83	71	.....
Total	.....	.....	8.00	.....	.....	10.14	.....	.....	5.67
Mean	83.0	62.9	.....	84.5	66.2	.....	83.2	64.2	.....

RESULTS.

The results, as indicated below, are due entirely to spraying, no effort having been made to check the rot by any other measure. No mummies or cankers were removed, and the apples that became infected were allowed to remain on the trees until the crop was picked or until they dropped. Those that fell to the ground were left under the trees until picking time. The hands that worked in the orchard were specially instructed not to remove any of the diseased apples from the experimental block. The object was to test the value of Bordeaux mixture under the most adverse conditions, and all possible sources of infection were left undisturbed.

On July 10, specimens of bitter-rot apples, some of which are shown in Plate I, could be found here and there in the orchard, especially on unsprayed trees, and two weeks later (July 24) each tree was examined by walking around it and looking for infected fruits. The diseased fruits were counted, and a general idea of the condition on that date may be conveyed by the following summary of the notes made at that time:

On each of the checks (A to E) 100 to 250 affected fruits were

counted without climbing the trees, which probably means an infection of 10 to 15 per cent of the crop, since there must have been many diseased fruits unseen.

Plot 1 showed about 21 diseased fruits on each tree.

Plot 2 showed 5 diseased fruits on one tree and 6 on the other.

Plots 3, 4, and 5 showed 1 to 3 diseased fruits on each tree.

Plot 6 showed no rot.

Plots 7 and 8 showed 9 to 30 diseased fruits on each tree.

Plots 9 and 10 showed 7 to 18 diseased fruits on each tree.

Plot 11 showed 22 diseased fruits on one and 36 on the other tree.

Plot 12, which had not been sprayed, showed 112 diseased fruits on one and 150 on the other tree.

Plot 15 showed 25 affected fruits on one tree and 35 on the other.

Plot 16 showed 6 affected fruits on one tree and 10 on the other.

Plot 17 was apparently still free from bitter-rot.

The above is sufficient to indicate that in practically every tree there was an abundant supply of spores for a serious outbreak of the disease, and that wherever Bordeaux mixture was lacking the fungus became rampant.

It was almost impossible with the equipment used to spray the tops of most of the trees thoroughly, and later examinations showed that some bitter-rot occurred in the top of every tree. Every rain must have washed down an abundance of spores from diseased apples in the tops to fruits below.

In Table II the results from the two trees in each plot are combined. and the windfalls, both rotten and sound, are included. As a rule, half to three-fourths of the rotten fruit was on the ground at picking time. This was true of sprayed as well as unsprayed trees.

The crop of the experimental block was picked and sorted on September 19 to 23, inclusive, and the result from each tree kept separate. The fruit on the ground was picked up and classified into sound and rotten, and the fruit picked from the tree was likewise classified. Sound fruit constituted every apple free from bitter-rot, regardless of codling moth or scab. All fruits that were unmistakably affected with other rots, such as Sphæropsis, Penicillium, and Monilia, were discarded and not included in either class. As a rule, this did not exceed 3 per cent of the crop. Wherever there was any doubt, however, the trouble was charged to bitter-rot.

The final results of these experiments are shown in Table II, and it will be seen from this table that in every treated plot Bordeaux mixture had a beneficial effect regardless of the time of application, and that where the trees were properly sprayed the loss was less than 5 per cent of the crop, while the untreated trees suffered a total loss. It is rare that such results are obtained in the treatment of a plant disease. With the exception of leaf-curl of the peach, leaf-blight of the pear,

and possibly apple scab, these results would indicate that bitter-rot yields more completely to treatment than any other disease known to the writer. The infection period of bitter-rot being much longer, a greater number of applications are required to secure protection throughout the season, but it would seem that an apple coated with Bordeaux mixture would not be attacked by bitter-rot even under conditions otherwise most favorable to the fungus.

TABLE II.—*Scheme of spraying at Avon, Va., during the season of 1905, and its results.*

Plot numbers (2 trees to each plot).	Treatment with Bordeaux mixture (5-5-50 formula).										Picked Sept. 19 to 23.		
	Apr. 8.	May 1.	May 9.	June 12.	June 27.	July 10.	July 25.	Aug. 7.	Aug. 22.	Sept. 4.	Sound fruit.	Rotten fruit.	Percentage of sound fruit.
											Bushels.	*Bushels.*	
1	"	"	"								18.50	30.25	37.9
2	"	"	"	"	"						47.50	22.50	67.8
3	"	"	"	"	"	"	"				56.00	2.00	96.5
4	"	"	"	"	"	"	"	"			54.00	1.75	96.8
5	"	"	"	"	"	"	"	"	"		32.75	1.15	96.6
6	"	"	"	"	"	"	"	"	"	"	68.50	.70	98.9
A	Check—one untreated tree.										.00	10.00	[a] 00.0
7	"	"	"				"	"	"	"	56.50	14.00	80.1
8	"	"	"					"	"	"	7.00	6.50	51.8
9					"	"	"		"		28.50	6.00	82.6
B	Check—one untreated tree.										.00	17.00	[a] 00.0
10					"	"	"	"	"	"	59.00	6.50	90.0
11						"	"	"	"	"	42.25	6.50	86.6
12							"	"	"	"	28.50	24.75	53.5
C	Check—one untreated tree.										.00	13.00	00.0
D	Check—one untreated tree.										.00	20.75	[a] 00.0
15						"	"	"	"		52.25	5.25	90.8
16					"	"	"	"			52.50	3.75	93.3
17				"	"	"	"				40.00	5.00	88.8
E	Check—one untreated tree.										.25	16.25	1.5

[a] Of the check trees, A had 1 sound apple, B 6, and D 2, but the percentages were too small to show in the table.

In the first column on the left of this table the numbers of the sprayed plots are given in figures and the unsprayed trees are indicated by letters. The dates of the applications are given at the heads of succeeding columns, and the ditto marks after each plot number refer to these dates. For example, the marks after Plot No. 1 indicate that this plot was sprayed April 8, May 1, and May 9; while Plot No. 12 was sprayed July 25, August 7 and 22, and September 4. The three columns on the right show the results in bushels of sound fruit, bushels of rotten fruit, and percentage of sound fruit for each plot, as determined when the crop was picked, September 19 to 23. The check plots are placed in the table about as they occurred in the orchard, Plot A being located near the lower side, while Plot E is at the upper side.

Plot 1, as will be seen from the table, received but three applications (those usually given in the treatment of apple scab), on April 8, May 1, and May 9, with the result that only 37.9 per cent of the fruit was saved from bitter-rot, showing that the treatment was stopped too early. (Pl. V, fig. 1.)

Plot 2 received, in addition to these three treatments, one on June 12, after an interval of 33 days, and a fifth application on June 27, with the result that 67.8 per cent of the crop was saved.

Plot 3 received, in addition to the foregoing treatments, one application on July 10 and another on July 25, making seven in all, with the result that 96.5 per cent of the crop was saved. (See Pl. III, fig. 1.)

Plot 4 received eight treatments, the dates being the same as in Plot 3, with an additional application on August 7. The percentage of sound fruit was 96.8.

Plot 5 received an additional treatment August 22, making nine applications in all, with the saving of 96.6 per cent of the crop.

Plot 6 was sprayed as in Plot 5, with an additional treatment on September 4, thus receiving an application on every spraying date, or a total of ten, the largest number given any plot in the experiment. The result was a saving of 98.9 per cent of the crop. (Pl. IV, fig. 1.)

Check A, which consisted of one untreated tree, yielded only one sound fruit and 10 bushels of rotten fruit. (Pl. III, fig. 2, and Pl. VII.)

Plot 7 received the first three applications, namely, on April 8, May 1, and May 9; and the last four, namely, on July 25, August 7, August 22, and September 4, leaving an interval of about two months and a half during which the trees were not sprayed. This interval was too long, as indicated by the yield of only 80.1 per cent of sound fruit.

Plot 8 was sprayed on the same dates as Plot 7, with the omission of the application on July 25, so that the interval during which the trees were not sprayed was about three months, resulting in a saving of only 51.7 per cent of the crop.

Plot 9 received applications 5, 6, 7, and 9, namely, on June 27, July 10, July 25, and August 22, 82.6 per cent of the crop being saved.

Check B, consisting of one untreated tree, yielded 17 bushels of rotten fruit and only six sound apples.

Plot 10 received applications 5 to 10, namely, on June 27, July 10, July 25, August 7, August 22, and September 4, 90 per cent of the fruit being saved.

Plot 11 differed from Plot 10 in that the treatment of June 27 was omitted. As a result of these five applications, 86.6 per cent of the crop was saved.

Plot 12 received one application less than Plot 11, the first treatment occurring July 25. Only 53.5 per cent of the crop was saved. (Pl. V, fig. 2.)

Check C, which consisted of one unsprayed tree, had 13 bushels of rotten fruit and no sound fruit, the entire crop having been destroyed.

Check D, one untreated tree, yielded 20¾ bushels of rotten fruit and only two sound apples. (Pl. IV, fig. 2.)

Plot 15 was sprayed on July 10, July 25, August 7, and August 22, and yielded 90.8 per cent of sound fruit.

Plot 16 received the same number of treatments as Plot 15, but the spraying was begun and ended two weeks earlier, the first application being made on June 27 and the last August 7. As a result 93.3 per cent of sound fruit was obtained. (Pl. VI, fig. 2.)

Plot 17 also received four applications at intervals of two weeks, but the treatment was begun two weeks earlier than in Plot 16, the spraying dates being June 12, June 27, July 10, and July 25. The yield of sound fruit was 88.8 per cent.

Check E, one untreated tree, yielded one-fourth bushel of sound fruit and 16¼ bushels of rotten fruit, the percentage of sound fruit being 1.5.

BENEFICIAL EFFECTS OF SPRAYING.

In analyzing the results as shown in Table II it is not difficult to conclude that in Plots 1 and 2 spraying was stopped too early, that in Plot 12 spraying was begun too late, and that in Plots 7 and 8 the interval between the early and late applications was too long. From Plots 3 to 6, as compared with Plots 1, 2, 7, 8, and 12, and the checks, it is also plainly evident that bitter-rot can be completely controlled by coating the fruit with Bordeaux mixture before infection takes place and keeping it thoroughly coated throughout the season. Moreover, Plots 10, 11, 15, 16, and 17 seem to indicate that, so far as bitter-rot is concerned, spraying before the trees bloom and within a month after the blooming period is not absolutely necessary. It is clearly seen by comparison, however, that the three early applications (April 8, May 1, and May 9) had a decidedly beneficial effect in all the plots that received them. Compare Plot 1, which received only these three applications and yielded 37.9 per cent of sound fruit, with the unsprayed trees, A to E, which yielded practically no sound fruit. Plot 12, which received four late applications (July 25, August 7, August 22, and September 4), gave only 53.5 per cent of sound fruit, while Plot 7, which had the same treatment and in addition the three early applications, gave 80.1 per cent of sound fruit. The three early applications thoroughly coated the branches and leaves, as well as the very young fruit, and it is probable that protection from infection was prolonged by the action of the rains in washing the copper from the leaves to the fruits. Of the several plots receiving only four applications each, No. 16, which received its first application on June 27, gave the best results, yielding 93.3 per cent of sound fruit. However, Plot 17, which had its first application two weeks earlier and yielded 88.8 per cent of sound fruit, would perhaps have shown up as well as No. 16 but for the fact that the upper side of one of the trees could not be properly reached with the spray. It appears, therefore, from this

group of plots that the ideal treatment would have been five applications at intervals of two weeks, beginning June 12. Comparing Nos. 12 and 15, it is further noted that a delay of two weeks—from July 10, the date the first application was given No. 15, to July 25, the date treatment began on No. 12—made a difference of 37.3 per cent in favor of the earlier applications, representing the difference between success and failure.

Considering the series of Plots 2 to 8, which combine the three early applications for scab and the later applications for bitter-rot, No. 3 is the most satisfactory. This plot was sprayed seven times, namely, on April 8, May 1, and May 9 for scab, and on June 12, June 27, July 10, and July 25 for bitter-rot, and the result was 56 bushels of sound fruit and only 2 bushels of rotten fruit from the two trees, or 96.5 per cent of sound fruit. Plots 4, 5, and 6 each had a slightly larger percentage of sound fruit, but scarcely enough to pay for the additional spraying which they received. However, the bitter-rot fungus is so influenced by weather conditions that it is scarcely safe to follow No. 3 and stop spraying as early as July 25. The treatment (eight applications) given Plot 4 would doubtless be necessary in some seasons to prevent both scab and bitter-rot. The results obtained in Plots 15, 16, and 17 seem to indicate that four applications at intervals of two weeks, beginning June 12, June 27, or even as late as July 10, would be the most satisfactory treatment, when the cost of spraying is considered, but as a rule it pays to give three or four treatments earlier in the season for apple scab, leaf-spot, and codling moth, and, therefore, these early spring applications, combined with the early summer applications, undoubtedly give the most satisfactory results.

The lesson to be learned from Plots 7 and 8, as compared with Plot 6, is that the omission of the June and July applications is almost fatal to the crop. Comparing Plots 7 and 8, it is seen that the one extra application given to the former on July 25 resulted in a saving of 28.4 per cent over the latter. Again, comparing Plots 11 and 12, it is seen that one extra application given to the former on July 10 resulted in a saving of 33.1 per cent over the latter. These results emphasize the importance of spraying at the right time, and in order to be sure of covering the proper time the applications must be spread out over a long period.

EFFECT OF THE TREATMENT ON OTHER DISEASES.

Scab.—It is already well known that apple scab is easily controlled by spraying with Bordeaux mixture. This disease was completely prevented on the trees in the experimental plots receiving the three early applications, namely, first, just before the trees bloomed; second, as soon as the blossoms were shed, and third, eight days later. Some scab appeared on the trees not so treated, but this variety of apple

(Yellow Newtown) does not usually suffer from scab so much as some other varieties. The same treatment was given a block of Winesaps, with the result that the fruit at picking time showed practically no scab, while the three unsprayed trees left as checks had 80 per cent of the crop affected.

Leaf-spot.—The disease known as leaf-spot, which also yields readily to treatment, is very common in Virginia, causing considerable damage by defoliating the trees, and certain varieties of apples require treatment for this disease alone. Trees sprayed as early as June 12 held their foliage in fine condition until after the crop was harvested. The three early applications did not entirely prevent the leaf-spot disease, and the best results were obtained when the treatment was continued until July 25 or later. Winesaps that were sprayed as soon as the blossoms were shed, May 1, and at intervals of two weeks until three applications had been made, lost practically no foliage from leaf-spot. Also two trees sprayed on May 18, about three weeks after the blooming period, and on June 12 kept their foliage in perfect condition throughout the season. On the other hand three unsprayed Winesaps in the same orchard lost 50 to 75 per cent of their leaves by August 7, and most of those remaining on the trees at that date were affected. The unsprayed Yellow Newtowns, however, did not suffer half so much. The trees thus defoliated were not able to properly mature the fruit, which at picking time was perceptibly smaller than that of sprayed trees. In some cases the sprayed fruit was as much as one-fourth larger than that on the unsprayed trees.

Sooty-blotch.—Sooty-blotch also yielded very readily to treatment, the fruit on all the sprayed trees being clean, while a portion of the untreated fruit was more or less "clouded." The three early applications for scab appeared to be sufficient to control this fungus, though in severe cases two applications in July would no doubt be necessary to prevent the disease.

INJURIOUS EFFECTS OF THE TREATMENT.

Russeting.—The fruit on all of the trees that received the three early applications in the bitter-rot experiment on the Yellow Newtown apples developed russet spots or blotches due to the action of the copper. These blotches sometimes covered half of the apple, dwarfing the affected side. Usually, however, the spots were small and very irregular in shape, detracting little from the appearance of the apple. Fruits that did not receive these early sprayings were not affected, and the trouble seems to have resulted entirely from the two applications made to the young fruit on May 1 and 9. About 50 per cent of the fruit sprayed on these dates showed some russet spots, but the disfiguration was apparently not sufficient to affect its market value materially. When russeting is feared it might be advisable to use less bluestone and a greater quantity of lime in the preparation of

Bordeaux mixture for application to the very young fruit. The mixture used in spraying stone fruits (3 pounds of bluestone and 9 pounds of lime to 50 gallons of water) is suggested.

Coating of Bordeaux mixture.—The fruit from Plot 3, which received its last application on July 25, was practically free from Bordeaux mixture at picking time, September 19 to 23, the coating having weathered away. (Pl. III, fig. 1.)

The fruit from Plot 4, which received its last application on August 7, showed considerable Bordeaux mixture at picking time, but not sufficient to attract special notice.

The fruit from Plots 5 and 6, and, in fact, from all of the plots sprayed after August 7, was thoroughly coated with Bordeaux mixture at picking time. (See Pl. IV, fig. 1; Pl. V, fig. 2, and Pl. VI, fig. 2.)

The presence of Bordeaux mixture on the fruit when packed is certainly objectionable, but it was found that in picking, grading, and barreling the apples most of it was rubbed off. The crop from the sprayed trees, both in the experimental block and in Mr. Goodwin's main orchard, was sold at the highest price paid for Yellow Newtown apples in that section the past season, and the purchaser raised no objection to the coating of Bordeaux mixture and did not require the fruit to be wiped.

COMMERCIAL OPERATIONS.

The Bureau of Plant Industry furnished a number of its correspondents with suggestions for the treatment of bitter-rot, and during the past season the writer visited a few of the orchards that were sprayed in accordance with these suggestions, as well as others that had not been properly treated. In every case where Bordeaux mixture was applied at the proper time good results were secured. Even poor spraying had a decidedly beneficial effect. Owing to the steepness of the land or to some other obstacle, there were always some trees left untreated or but partially sprayed, thus affording ample checks with which to compare the treated trees. In most cases the results were very striking, showing almost a perfect crop on the sprayed trees and a loss of 75 to 100 per cent of the crop on the unsprayed trees. More striking still is the fact that where only one side of a tree was sprayed the crop on that side matured in perfect condition, while the crop on the opposite side was destroyed by bitter-rot. The writer observed this in a number of instances where a fence or a steep hillside admitted of the treatment of only one side of the trees.

RESULTS IN SEVERAL ORCHARDS.

Aside from the trees used in the experiment, Mr. W. H. Goodwin, of Avon, Va., sprayed the larger portion of his orchard under the

irections of the Bureau of Plant Industry, and the writer was able to ee the work in progress from time to time and to note the results.

The treatment consisted of eight applications of Bordeaux mixture, orresponding very closely to Plot 5 of the experiment, with the mission of the fourth application (June 12), and the results appeared o be equally as good as those obtained in that plot (96.6 per cent of ound fruit). The commercial spraying was done with the same outfit nd the same men employed in the experimental work and usually egan the day after that work was completed.

The results of this treatment are set forth very clearly in a letter rom Mr. Goodwin to the writer under date of November 3, 1905, s follows:

Replying to your favor of November 1, I have to say that in accordance with your irections I sprayed the major portion of my orchard of Albemarle Pippins eight times, eginning the applications on the following dates: April 9, May 2, May 10, June 28, uly 11, July 26, August 10, and August 26. The portion of the orchard thus prayed had practically no bitter-rot—perhaps not more than 2 per cent. On the ther hand, the fruit on some 250 trees which could not be sprayed owing to steepness f land and lack of water was almost entirely lost from the bitter-rot. The crop on his portion of the orchard was estimated at about 800 barrels; but at picking time here were no No. 1's, and only 134 barrels of No. 2's (nearly all of which were more r less specked) were gathered.

I am fully convinced that the bitter-rot may be almost entirely prevented by roper spraying with Bordeaux mixture, and in my opinion the establishment of his fact has reclaimed the pippin industry in Virginia. The last two crops were ntirely lost from bitter-rot, whereas the crop the present year was saved by spraying. My trees are from 12 to 23 years old, and averaged about 3 barrels per tree. The trees were very thoroughly sprayed, costing for the eight applications about 30 ents per tree.

The orchard referred to was examined from time to time during the season, and on July 10 a few apples affected with bitter-rot were found, perhaps an average of less than one to each tree in the sprayed portion, and slightly more on unsprayed trees. By August 21, 75 per cent of the crop on most of the unsprayed trees was destroyed, and the fruit out of reach of the spray on the topmost branches of some of the tallest trees in the sprayed portion was badly affected, while all trees properly treated showed practically no rot. On a certain steep hillside the end tree in each row could be sprayed only on one side, resulting in a full crop of sound fruit on the sprayed half of the tree, while practically all of the fruit rotted on the other half.

Mr. William B. MacGregor, of Avon, Va., whose orchard is adjacent to the Goodwin orchard, sprayed his trees very thoroughly and persistently throughout the season, and was rewarded with a magnificent crop of almost perfect fruit. The writer had opportunities to visit this orchard while the spraying work was being done, and also at picking time. The course of treatment and summary of results are

given in a letter from Mr. MacGregor, dated November 10, 1905, as follows:

In reply to yours of October 31, I do not know the exact dates of spraying. In the part where the most spraying was done the first application was made about April 15, followed by others on May 7, June 1, and at intervals of from 13 to 17 days thereafter until September 1, making nine applications in all. Practically no rot appeared on this part. On trees not sprayed till June 1 the rot might be 3 per cent, but not more. On three trees not sprayed August 1, but which received all the other applications, no difference was noted. Applications must be thorough. Some of our trees had only a few apples, and to save time we tried to spray them only in July and August. Result, 25 per cent bitter-rot at least.

The orchard of Messrs. J. W. Rodes and Sons is located in the Rockfish Valley, about eighteen miles from Afton, Va. Mr. Rodes corresponded with the Bureau of Plant Industry concerning the treatment of the bitter-rot disease, and on July 26 the writer visited the orchard. The appearance of the trees indicated that they had been thoroughly sprayed with Bordeaux mixture, and on that date Mr. Rodes was spraying the tops of his tallest trees with an extra long extension rod, made by joining two rods of his outfit into one. He realized the importance of reaching every fruit with the mixture. With the exception of an occasional diseased fruit the sprayed portion of the crop throughout the orchard was free from bitter-rot. However, on one side of the orchard a fence interfered with the spraying, and about one-third of the crop on each of several trees could not be easily reached. In every such case the unsprayed section of the tree showed a serious outbreak of bitter-rot. A letter from Mr. S. T. Rodes, dated at Bryant, Va., November 3, 1905, and giving a statement of the treatment and the results obtained follows:

Yours of October 31 to hand and contents noted. In reply will say we sprayed our orchard of 275 Albemarle Pippins six times for bitter-rot, starting on the dates given below and finishing as soon as possible. [Mr. Rodes then names the dates of commencing six successive sprayings, as follows: June 15, July 3, 15, and 31, August 17 and 30.]

Where we could get at the trees and made the six applications there was no bitter-rot worth mentioning—scarcely any at all. Some trees that we could not spray on both sides on account of the fence showed quite a difference, the side sprayed having nice, clean apples, clear from cloud and rot, the fruit on the other side, unsprayed, being clouded and nearly all infested with the bitter-rot.

Two years ago I believe the trees bore as many apples as they did this year. We did not spray them, however, and gathered only 56 barrels. From the same trees this year, but well sprayed inside and out, we gathered 1,142 barrels of No. 1 Pippins.

In unsprayed and poorly sprayed orchards in the Rockfish Valley bitter-rot was exceedingly bad, and there can be no doubt that the freedom from the disease in the sprayed orchards was due entirely to the treatment.

PREPARATION OF BORDEAUX MIXTUR

The Bordeaux mixture used in the experiments was pı ing to the following formula:

5 pounds of copper sulphate (bluestone).
5 pounds of fresh stone lime.
50 gallons of water.

For small lots dissolve the bluestone in 25 gallons of separate vessel slake the lime by sprinkling it with wat paste is formed, and then dilute it to 25 gallons. The solutions together through a strainer into the spray receptacle, a bucketful of each at the same time. Wl stirred, the mixture is ready for application.

For extensive spraying, stock solutions should be prep out 50 pounds of bluestone into a coarse bag and sı 50-gallon barrel of water near the top. The bluestone ı will usually dissolve within twenty-four hours, and th then be filled to the 50-gallon mark. Each gallon of thi tains 1 pound of bluestone. Likewise 50 pounds of li a barrel and slaked by slowly pouring water over it. keep it thoroughly stirred with a shovel, and continu enough to keep it from burning, but the mass shoul merged. When thoroughly slaked, dilute to 50 gallons will then contain the equivalent of 1 pound of lime, thoroughly agitated. Therefore, in order to make up the mixture take 5 gallons of the bluestone solution of the lime water. To prepare 200 gallons of the mixtı tank of that capacity 20 gallons of each constituent wou but it should be remembered that these concentrated sc be diluted before pouring them together.

In order to save so much dipping, the mixing should elevated platform, such as shown in Plate VIII, figur form shown in this illustration was constructed at th gestion by Mr. W. H. Goodwin for use in the bitter-ro as well as for his commercial work, and is about 2 fe the top of the spray tank on the wagon. The stock kept in 50-gallon barrels on the rear of the platform dilution tanks, holding 100 gallons each, are placed at of the platform. The bluestone solution is placed in one and the lime water in the other. Then each is filled wi the 50, 75, or 100 gallon mark, as desired. A molasses g is fixed in a hole bored near the bottom of each tank, an with an open trough leading to the strainer in the spra of these gates is opened at the same time, and thus th are allowed to run together into the spray tank. Ir

water came from a spring about 100 yards above the platform, and was conducted into the barrels and tanks on the platform through open troughs. Where the convenience of an elevated spring is lacking, the water may be pumped up by hand, windmill, or engine.

METHOD OF APPLYING BORDEAUX MIXTURE.

The following account of the method of applying the Bordeaux mixture in the experiments of the Bureau of Plant Industry may perhaps serve as a guide to fruit growers in treating their orchards. One can not emphasize too strongly the necessity of reaching every part of the tree with the spray and coating the fruits on all sides.

The spraying was done with a specially constructed pump and a tank of 200 gallons capacity. The pump is fitted with two sections of ½-inch hose, each 25 feet long, with a 14-foot bamboo extension rod attached and double Vermorel nozzles. This outfit is seen in operation in Plate VIII, figure 2. When convenient two trees were sprayed at the same time, and the operators were thus kept out of each other's way. In spraying the tall trees the operator had to stand on the spray tank or climb the tree. Where the conditions will admit, an elevated platform built on top of the spray tank should be used for this purpose, but in the case here mentioned the land was too steep.

In making the first application great care was taken to coat the bark thoroughly from the ground to the tips of the twigs, but later applications were aimed at the fruit and foliage only. Nozzles with small apertures were used and the pressure was kept as high as one could maintain it with a hand pump. This produced a fine mist, and the attempt was made to spray the tree so thoroughly as to envelop every apple in this mist. So far as practicable, the trees were sprayed from every direction so as to hit every apple all over. When it could be avoided, the trees were not left dripping, the aim being to pepper the fruit and leaves thoroughly without producing drops large enough to run off. Good spraying does not consist in drenching the tree.

For extensive operations some form of power sprayer should be used where the conditions are suitable. Gasoline sprayers are perhaps the most promising, but in some instances they have been disappointing.

CONCLUSIONS AND RECOMMENDATIONS.

Summarizing the results obtained, and considering the fact that the experiments were made during a season unusually favorable to bitter-rot, the following conclusions may be drawn:

1. Bitter-rot can be completely controlled by proper applications of Bordeaux mixture, 93.3 to 98.9 per cent of sound fruit having been saved by such treatment in these experiments, while the checks rotted completely.

2. Four applications, when made just at the right time, are sufficient to control the disease satisfactorily, but in order to be sure of covering the infection periods one or two additional applications may be necessary.

3. The applications should be made at intervals of two weeks, beginning about six weeks after the trees bloom.

4. It is necessary to spray the trees thoroughly, coating the fruit on all sides with fine mist-like applications.

5. Other diseases, such as scab, leaf-spot, and sooty-blotch, may be controlled in connection with the treatment of bitter-rot.

For the treatment of bitter-rot alone, spray the trees thoroughly with Bordeaux mixture at intervals of two weeks until five applications have been made, beginning not later than forty days after the petals have fallen (in Virginia usually about June 10 to 15).

For the combined treatment of apple scab and bitter-rot, spray the trees with Bordeaux mixture (1) just before they bloom (but after the cluster buds have opened and exposed the flower buds); (2) as soon as the petals fall; (3) a week or ten days later; and (4) about forty to fifty days after the shedding of the petals, and at intervals of two weeks thereafter until, in all, seven or eight applications have been made.

It is true, of course, that the number of applications required and the dates on which they should be made depend to a considerable extent upon the season, but the treatment should always begin before the infection period, which may occur as early as forty to fifty days after the fruit has set (in Virginia, perhaps by the middle of June in some seasons).

In a dry or cool season the intervals between the later sprayings may be lengthened, thus reducing the number of applications required, provided the fruit is first thoroughly coated, which will necessitate at least two applications.

On the other hand, in a hot, humid season it will probably be necessary to shorten the intervals and increase the total number of applications.

Should, for any reason, the treatment be delayed until after it is discovered that infection has taken place, the trees should be thorougly sprayed twice in rapid succession with an interval of only a few days, in order to coat the fruit thoroughly as quickly as possible. With one application alone it is difficult to coat the fruits sufficiently to protect against bitter-rot, and the second application, which adheres better than the first on account of the presence of the previous coating and also reaches parts of the fruit not touched before, is necessary for thorough protection.

THE PHILADELPHIA
MAR 27 1906
MUSEUMS

PLATES.

DESCRIPTION OF PLATES.

PLATE I. (*Frontispiece.*) Three apples affected with bitter-rot and three mummies which presumably furnished the infection. The twigs with these fruits and mummies attached were cut from one of the unsprayed trees in the experimental orchard on July 10, and the photograph was made two days later.

PLATE II. The microscopic characters of the bitter-rot fungus (*Glomerella rufomaculans* (Berk.) Spaulding & von Schrenk): *1.*—Five asci, each containing eight ascospores; also one probably immature ascus. × 900. *2.*—A group of free ascospores. × 900. *3.*—A group of ascospores germinating in a drop of water. × 900. *4.*—Spore-bearing hyphæ springing from a mycelium growing in nutrient agar: *a*, the mycelium giving rise to the fertile hyphæ; *b*, a group of conidia, or summer spores, newly born. × 600. *5.*—A group of germinating conidia. × 740. *6.*—A section through a pustule showing the ruptured skin of the apple, the spore-bearing hyphæ, and the free conidia. × 200.

PLATE III. Fig. 1.—The crop picked from one tree of Plot 3, showing 33¼ bushels of sound fruit on the left and 1¾ bushels of rotten fruit on the right. Fig. 2.—Fruit from an untreated tree (Check A). The only sound apple from the tree is shown on top of the basket.

PLATE IV. Fig. 1.—Crop picked from one of the trees in Plot 6, showing 39 bushels of sound fruit and less than a peck of rotten fruit in the half-bushel measure on top of the pile. The fruit still shows a coating of Bordeaux mixture. Fig. 2.—The crop from an unsprayed tree (Check D), showing only two sound apples, which are placed on a board on top of the heap of rotten fruit.

PLATE V. Fig. 1.—Fruit from one of the trees in Plot 1, showing 13¼ bushels of bitter-rot apples on the right, and 10 bushels of sound apples on the left; treatment too early for best results. Fig. 2.—The fruit from Plot 12, showing 12 bushels of sound apples on the right, and 12¾ bushels of rotten fruit on the left: treatment too late to save the crop.

PLATE VI. Fig. 1.—A yellow Newtown apple badly affected with bitter-rot, and another recently mummified by the fungus. The specimen designated *A* shows a typical case of bitter-rot on a Yellow Newtown apple. The fruit was taken from the tree in this condition. The apple marked *B* has been recently mummified by bitter-rot, the entire fruit having become involved in decay. Fig. 2.—Apples harvested from one tree in Plot 16, showing 28½ bushels of sound fruit above and to the left, and 1½ bushels of rotten fruit in and near the baskets.

PLATE VII. An unsprayed tree (Check A) with most of its crop on the ground at picking time, illustrating the destructive work of the bitter-rot.

PLATE VIII. Fig. 1.—The platform and equipment used in preparing Bordeaux mixture; also showing the spray tank receiving a supply of Bordeaux mixture. Fig. 2.—The spraying outfit in operation.

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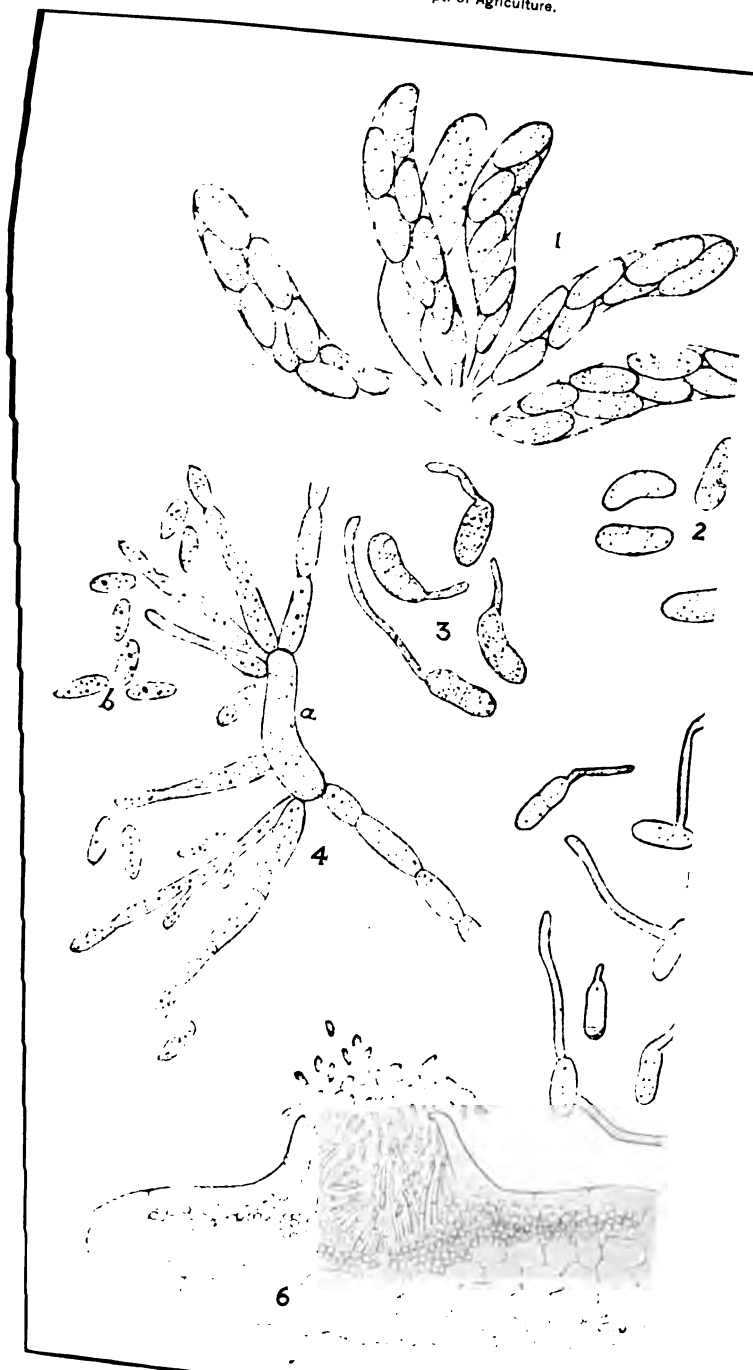

THE MICROSCOPIC CHARACTERS OF THE BITTER-ROT FUNGUS IN VA

FIG. 1.—CROP OF APPLES FROM ONE TREE OF PLOT 3, SPRAYED

FIG. 2.—CROP FROM AN UNSPRAYED TREE (CHECK A)

FIG. 1.—APPLES HARVESTED FROM ONE TREE OF PLOT 6, SPRAYED TEN TIMES.

FIG. 2.—CROP FROM AN UNSPRAYED TREE (CHECK D).

FIG. 1.—APPLES HARVESTED FROM ONE TREE OF PLOT 1, SPRAYED THREE TIMES; APPLICATIONS MADE TOO EARLY.

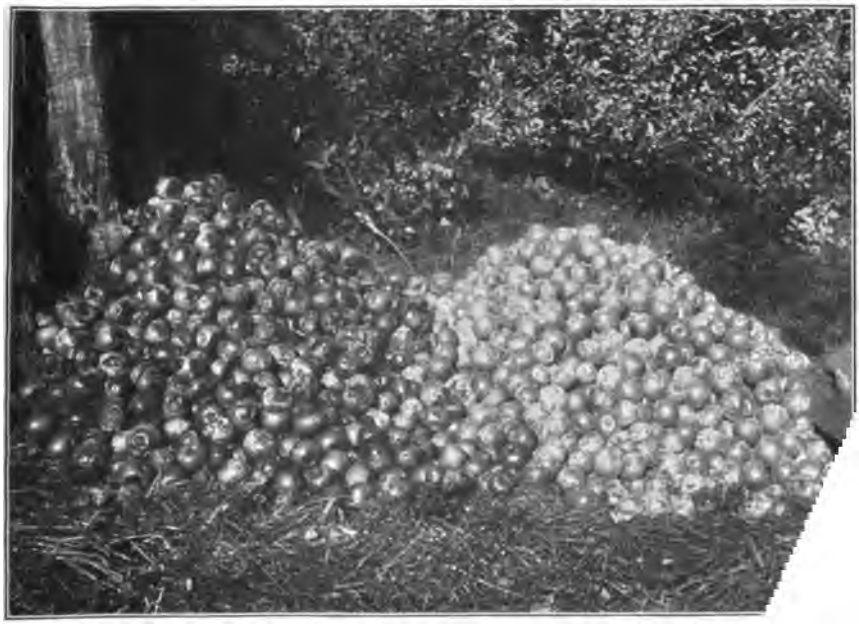

FIG. 2.—CROP OF APPLES FROM ONE TREE OF PLOT 12, SPRAYED FOUR APPLICATIONS MADE TOO LATE.

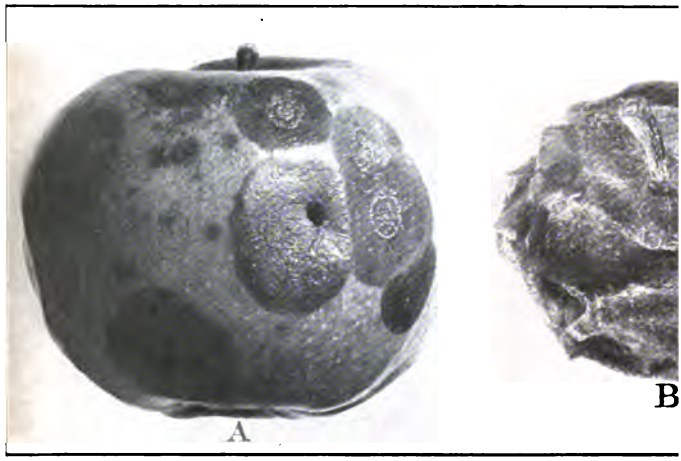

FIG. 1.—A YELLOW NEWTOWN APPLE (A) BADLY AFFECTED WITH BI
ANOTHER (B) RECENTLY MUMMIFIED BY THE FUNGUS.

FIG. 2.—THE CROP FROM ONE TREE OF PLOT 16, SPRAYED FOUR T
RIGHT PERIOD.

An Untreated Apple Tree (Check A), with the Bulk of its Crop on the Ground at Picking Time.

FIG. 1.—PLATFORM AND EQUIPMENT FOR MAKING BORDEAUX

FIG. 2.—THE SPRAYING OUTFIT IN OPERATION.

U. S. DEPARTMENT OF AGRICUL

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 94.

B. T. GALLOWAY, *Chief of Bureau.*

FARM PRACTICE WITH FORAGI IN WESTERN OREGON A WESTERN WASHINGTON

BY

BYRON HUNTER,

ASSISTANT AGRICULTURIST, FARM MANAGEMENT INVE

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., May 19, 1906.

SIR: I have the honor to transmit herewith, and to recommend for publication as Bulletin No. 94 of the series of this Bureau, the accompanying manuscript, entitled "Farm Practice with Forage Crops in Western Oregon and Western Washington."

This paper was prepared by Mr. Byron Hunter, Assistant Agriculturist, under the direction of the Agriculturist in charge of Farm Management Investigations and in cooperation with the State agricultural experiment stations of Oregon and Washington. Provision has been made for publication by these two experiment stations.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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FARM PRACTICE WITH FORAGE WESTERN OREGON AND WES WASHINGTON.

INTRODUCTION.

Although the average methods in farm practice in usually far below the highest possibilities, men are to and there who have worked out the problems of crop utilization in a satisfactory manner and who stand o successful farmers in their respective communities. B methods of a large number of such men it is possib large amount of valuable information that would r patient labor to glean from personal experience. D years the writer has had charge of forage plant ir the Pacific Northwest, considerable time has been sp lamette Valley and the region of Puget Sound studyi of the farmers most successful in growing and handlir In addition to the information obtained in this detail has been gleaned during thirty years' residence in the west, including nine years' residence in the Willamett bulletin is a result of this study, and the material h except as noted in the text, is based almost entirely mation obtained in this manner.

For the benefit of the readers of this bulletin not fa condition under which the crops discussed are grown tion of the region is given. Although much has regarding the superiority of legumes over other plar vators and food for farm animals, there are many in this bulletin is likely to fall who do not understand of this group of plants. For this reason a paragrap the nature of these plants and the methods of th For similar reasons the principles underlying hayn use of hay caps are discussed.

DESCRIPTION OF THE REGION.

What is said in these pages is applicable to all that region west of the Cascade Mountains in Oregon and Washington as far south as the upper portion of the Willamette Valley. With the exception of some of the mountainous areas the winters are mild. The summer months are comparatively dry, the nights are cool, and dews are frequent and heavy. The annual rainfall varies from about 20 inches in a small area where the Strait of San Juan de Fuca joins Puget Sound to more than 100 inches at several points along the Pacific coast. The main body of agricultural land about Puget Sound has an annual rainfall of 30 to 60 inches; that of the Willamette Valley 40 to 50 inches.

The average rainfall of this region for six years is shown in the following table:

Average monthly and annual rainfall at points in the States of Oregon and Washington.

Month.	Oregon.			Washington.		
	McMinnville.	Albany.	Salem.	Olympia.	Seattle.	Bellingham.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
January	7.04	5.48	6.15	8.25	3.93	3.34
February	6.38	6.22	4.17	7.08	4.57	2.69
March	5.71	5.06	4.61	5.17	3.26	2.72
April	3.25	2.41	4.07	4.32	2.38	2.64
May	2.04	1.47	3.42	3.06	2.03	2.52
June	1.15	.74	1.47	2.09	1.87	2.02
July	.53	.57	.28	.55	.82	1.14
August	.81	.82	.65	.68	.68	1.43
September	1.97	1.85	1.94	2.91	2.13	2.26
October	3.39	2.29	3.62	4.24	3.05	2.51
November	10.13	7.44	8.18	10.96	5.77	4.93
December	4.47	6.17	6.62	7.92	5.13	3.85
Yearly	46.87	40.52	45.18	57.25	35.62	32.05

It will be seen that the rainfall is light during summer, heaviest during winter, and quite well distributed throughout the remainder of the year. With its mild winters and abundant rainfall the region as a whole is exceedingly well adapted to forage plant production. Grasses remain green during the entire year, while the clovers, vetches, root crops, rape, and kale, with proper care, all yield abundantly.

In Oregon the Willamette Valley constitutes the major portion of the agricultural land of the region studied. When first brought into cultivation the valley soil was friable, easily tilled, and productive. For years the cereals were practically the only crops grown, and much of the land at the present time is still producing these crops exclusively. The average yield of wheat on such land at the present time is said to be as low as 10 or 12 bushels per acre. Formerly it was much higher. The growing of cereal crops year after year has

depleted the soil of much of its humus and rendered it
and difficult to work. Applications of barnyard n
growing of leguminous crops bring the soil back to its
and fertility, and since dairying and live-stock prod
come such important industries in the valley much
being rapidly restored to its former productiveness.

Western Washington is largely covered with a d
evergreen timber and underbrush. The prairie land
much of it is gravelly and of little agricultural valu
agricultural land was formerly timbered, and it h
eminently adapted to the production of forage cro
kinds of fruit. Clover has been one of the leading
and little of the land has been subjected to the exclu
of cereal crops. As might be expected, therefore, m
land of western Washington is still in a very product

HAYMAKING.

To make hay of prime quality west of the Cascad
often a difficult matter. Most of the hay crops, if all
naturally, are ready to cut during the month of June
spring rains are usually not over until the 1st of Ju
making would naturally occur at a time when good
always be relied upon. Even when the weather is
are cool and dews are frequent and heavy. This di
partially overcome by pasturing the meadows in t
about the 1st of May to retard the development of t
haymaking will occur after the late spring rains are

CONDITIONS GOVERNING STAGE AT WHICH HAY SHO

There are several factors to be considered in determi
stage at which a crop should be cut for hay. Chem
hay made from young growing plants is more digestil
more protein per pound than hay made from more
If hay is cut early the percentage of protein is great
the percentage of protein is less, but the yield of dry n
is materially increased. As an illustration of this, se
ing the amount of dry matter in corn at different st
ment, page 29. The protein content of hay made
grasses, such as timothy or orchard grass, is always lo
in protein per pound from cutting such hay early
than counterbalanced by the loss in dry matter. On
hay made from some of the leguminous plants is sai
for certain classes of animals. Men who have h
experience in feeding vetch and alfalfa hay generally

that either is too strong a feed for horses, especially if cut very green. For this reason hay made from leguminous crops is frequently cut much riper if for horses than when intended for other animals.

Laxative feeding stuffs are undesirable for horses, but not for cows. Green hay is laxative in character, while hay cut in a more mature condition has an opposite tendency. The stage at which hay should be cut, therefore, will depend upon the class of animals for which it is intended.

The number of times a meadow is to be cut during a season is another factor in the time for cutting hay that must not be overlooked. If there is to be but one cutting, the greatest yield will be secured by allowing the crop to become quite well matured before it is cut. When two cuttings are to be made, farmers who have tried the experiment find that the greatest yield is secured by cutting the first crop while it is still green and growing and before the dry season has begun. The ordinary hay plants are not inclined to continue their growth after the first cutting if allowed to stand until their seed is pretty well formed. A delay of only a few days in cutting the first crop of the season often seriously affects the growth of the second.

A statement of the time for cutting will be found under the special discussion of each crop.

CURING HAY.

The best hay is made without rain and with the least possible amount of sunshine. If it were possible to cure hay in the shade, the quality would be much better. The curing of hay is a process of drying and of fermentation. Hot sun tends to stop fermentations which produce hay of good quality.[a]

From what is said above it is evident that hay should remain in the swath only until dry enough to be raked evenly into windrows; that most of the curing should take place in the cock rather than in the swath or windrow; and that, just as quickly as it is safe to do so, it should be placed in the stack or mow. With fair weather and hot sun, light crops may be raked soon after mowing, often in two or three hours. Heavier crops, especially when green, require more time. When the growth is heavy the swath is often packed so closely to the ground from its own weight and the pressure of the wheels of the mower that the use of the tedder is necessary to dry it out evenly.

West of the Cascade Mountains hay is generally put up in permanent cocks, where it remains for a week or ten days. If it is to remain in the field but a short time some farmers cure it quickly by first putting it into small, flat cocks. In about twenty-four hours these are turned over, allowed to air, and three or four of them are then made into one permanent cock. At what stage hay should be stacked is a question upon which there are many opinions. A com-

[a] W. J. Spillman, in "Farm Grasses of the United States."

mon rule with many farmers is to stack when juice can out of a wisp of hay taken from the middle of the coc

As stated, the common practice in this region is to in the field for about a week; in fact, a very large maj ers think good hay can be made in no other way und conditions west of the Cascade Mountains. There ar ful men, however, who put up hay by what has be "rapid process." With good haying weather the metl follows: The grass is cut in the afternoon. Being un night's dew does not injure it. If the crop is heavy started the next morning as soon as the dew has dri hay is gone over as many times as possible during before evening it is raked and cocked. The hay ther field for two nights and a day and until the dew is off t The cocks are then scattered and aired, especially the b of them, and the hay is hauled to the mow during the requires three days from cutting to hauling. The h evenly in the mow so that it may all settle alike and e air as possible, and is salted at the rate of 10 pound night the barn is tightly closed to keep out damp air.

HAY CAPS.

When the price of hay is high, it is quite probable can be used profitably in making hay west of the Casc The use of caps would prevent the outside of the cock ing too dry, and would thus add to the total weight The quality of the hay would be greatly improved, f practically uniform throughout. The use of caps wou increase the certainty of saving the crop. A farmer used hay caps for ten years. He thinks they materiall the quality and the quantity of his hay. Unfortunate present no hay caps on the market. However, they m light canvas or any strong cotton cloth in sizes to su 5 feet square, with pegs or weights attached to hold when in use, ought to give satisfactory service. A coa be applied to one side of the cloth. The caps should a after being used, for they will mold if piled up wet.

THE SILO.

That the silo should have a very general use in w and western Washington, not only for the preservati for many other crops as well, ought to be apparent f standing of the climatic conditions of the region. stated, most of the hay crops are ready to cut during

June, while spring rains frequently continue until about the 1st of July. (See table giving the distribution of rainfall on page 8.) It will thus be seen that haymaking ordinarily occurs at a time when good weather can not always be relied upon. If meadows are pastured during the spring to retard the development of the crop, so that haymaking will occur after the late spring rains are over, the yield of the second crop is usually much lighter, since its growth is confined entirely to the dry season. By the use of the silo, on the other hand, the first crop may be cut for ensilage early in June, even though the weather be unfavorable for haymaking. If cut at this time, while the plants are still growing vigorously, a good second crop will usually mature for hay early in August—the best haying season of the year. A light third crop can be used for pasture or cut for ensilage late in the fall. It is evident, therefore, that the use of the silo will practically insure the saving of the first crop, increase the total yield per acre, and cause the second crop to mature at a time when good haying weather can usually be relied upon.

That all kinds of ensilage should be finely cut may be desirable, but we must not get the idea that it is essential. For years ensilage of the finest quality has been made in western Oregon and western Washington out of whole clover and grass (timothy, English ryegrass, etc.). In making ensilage of this kind, however, there are two essentials—an air-tight silo and great care in filling it.

Farmers who use the silo as indicated above agree that the first crop of grass and clover should be cut for ensilage from the 1st to the 15th of June, for the earlier the first crop is cut the greater will be the yield of the second.

Difficulty is usually experienced in raking up freshly cut green grass with an ordinary hayrake. Some farmers avoid this difficulty by cutting with a self-raking reaper or a mower with a buncher attachment. These bunches are then thrown on a wagon by hand. Others cut with an ordinary mower and load from the swath with a hay loader. The heavy green grass often bends the teeth on the elevator bars of the loader. The teeth may be reenforced by nailing blocks of wood on the elevator bars just back of the teeth.

In filling the silo the material must be evenly spread and thoroughly tramped, so that all of the air possible will be excluded. If this is not done much of the ensilage will spoil. Two principal methods were found in use by farmers in filling silos. In the first the freshly cut grass is dropped directly into the silo with a hayfork. Two men in the silo spread the material and tramp it thoroughly, especially around the edges. The center of the silo where the loads from the fork fall requires but little tramping. The second method is to drop the material upon a platform at the top of the silo by means of hay

slings or a hayfork. A man upon the platform thro\ into the silo, placing it as best he can. Another r evenly in the silo and tramps it thoroughly. This safest method, for there is less chance to slight the wo days after the silo has been filled, the settling of th allow the addition of two or three loads each day, e thoroughly tramped when added. When the filling is top is covered about 1 foot deep with marsh grass material that will pack closely and exclude the air. thoroughly and tramped daily for several days, usin rels of water at each wetting. The writer has seen en lent quality made from whole grass in this way. H ensilage made by dropping the material into the silo \ ing and tramping that was practically a total loss.

THE NATURE OF LEGUMINOUS PLANT

Plants that produce their seed in two-valved pods beans, vetch, and alfalfa, are called legumes. The family of plants as soil renovators has long been rec just what way they are capable of restoring fertility not been understood until recent years. If the roots o plant be carefully removed from the soil little lumps, or tubercles, will usually be found upon them. The in size with different legumes and may be found alon On the roots of red clover they are about twice as la of that plant. The nodules are caused by bacteria th in the roots.

By the aid of the bacteria living in the nodules, leg are enabled to assimilate atmospheric nitrogen. Sin stitutes approximately four-fifths of the atmosphere plants has an inexhaustible supply of this important ment. Other plants can not assimilate the nitroge phere; they can obtain it only from decaying orga from commercial fertilizers containing nitrogen. Ch show the tisues of leguminous plants to be very ri hence the value of these plants when plowed under a The roots of a clover crop ordinarily contain more ni whole crop removes from the soil. As these roots food in them becomes available for other plants. Nit the first element of plant food that needs renewing; value of leguminous plants as soil renovators.

Generally speaking, the nodules of each kind of le by certain kinds of bacteria. Thus there is one k another for red clover, another for common vetch,

any rate the nodule-forming bacteria of red clover, for example, have become so accustomed to that plant that they are of little or no value in forming nodules on the roots of most other legumes. If nodule-forming bacteria are not in the soil no nodules will be formed; the failure of leguminous crops is often due to this cause. These bacteria may be artificially supplied in two ways, namely, by means of pure cultures of the bacteria and by transferring soil from one field to another. For further information regarding these two methods, see page 24. See also Farmers' Bulletin No. 240, U. S. Department of Agriculture.

FORAGE CROPS.

In the pages that follow, only those crops are discussed that have an important place in the agriculture of the region. What is said regarding methods of seeding, culture, and feeding these crops is based almost entirely upon the farm practice of the region.

RED CLOVER.

Considering the region as a whole, red clover (*Trifolium pratense*) is easily the leading forage plant west of the Cascade Mountains. It thrives best on rich, well-drained upland soils. Many of the low lands that are too wet and cold for red clover become adapted to it when properly drained. If allowed to develop naturally, this crop matures for hay early in June. Rains are not infrequent at this season of the year, and it is a common practice to pasture red clover in the spring until about the first of May to retard the development of the crop, so that haymaking will occur during good weather. Red clover begins to grow in the early spring and, unless the soil is very poor and the summer very dry, remains green and furnishes excellent pasture until early in December.

Generally speaking, red clover reaches its highest development on the coast and the region about Puget Sound, where, under favorable conditions, it may be cut three times during the year. To give three crops it must be grown on rich lands and must not be pastured in the early spring. The first crop should be cut for hay or ensilage early in June, the second for hay in August, and the third for ensilage late in the fall. In the Willamette Valley difficulty is often experienced in getting red clover established, especially on land that has produced cereal crops exclusively for years. This difficulty is probably due to the methods of seeding, the dry summers, the poor texture of the soil, the lack of available nitrogen, and possibly the lack of nodule-forming bacteria. Red clover also frequently runs out in a short time. It is believed by farmers that this is due to the ravages of the clover root borer. In spite of these difficulties, how-

ever, red clover is one of the leading forage plants of the Willamette Valley. It is not unreasonable to assume that these hindrances to the growth of red clover are largely responsible for the important place that common vetch occupies in the agriculture of western Oregon.

In the Willamette Valley it is a common practice to apply land plaster to clover in the spring, during March and April. From 40 to 60 pounds per acre applied on the surface of the ground in the early spring are said to double the yield of both hay and seed. Land plaster has the same effect when applied to other leguminous crops in this region, but it is essential that it be applied early enough to receive an abundance of rain.

METHODS OF SOWING.

There are many methods in use for sowing red clover in western Oregon and western Washington, some of which are given below:

(1) *Clover with early-sown winter wheat.*—From 8 to 12 pounds of clover seed per acre are sown in the early fall with winter wheat on land that has been summer fallowed or from which an early cultivated crop has been removed. The seed is usually sown broadcast and covered with a harrow. If the clover fails to catch it can be sown again in the spring, about the 1st of March.

(2) *Clover with late-sown winter wheat.*—Early in the spring, about the 1st of March, when the ground is heaving slightly from alternate thawing and freezing, from 8 to 10 pounds of clover seed per acre are sown broadcast on late-sown winter wheat. If the ground is dry enough when the clover seed is sown it may be covered with a harrow.

(3) *Clover with spring oats or wheat.*—With this method a good seed bed is essential. The land should be plowed deep in the late fall or winter, and as soon as in good working condition in the spring it should be cultivated until it is in perfect tilth. If the soil is inclined to run together it may be necessary to replow in the spring. Instead of plowing in the fall or winter it may be done in the early spring and the seed bed prepared immediately. After drilling in a full crop of oats or wheat, from 10 to 12 pounds of clover seed per acre are sown and covered with a harrow. In western Washington this is the usual method, with the exception that either timothy, English rye-grass, or orchard grass is usually sown with the grain and clover. On wet land alsike clover often forms a part of the mixture.

(4) *Clover alone.*—When clover is sown alone in the spring the land is plowed early and worked down fine. About the 1st of May it is again thoroughly cultivated to kill weeds and prepare the seed bed. From 10 to 12 pounds of clover seed per acre are then sown

and covered by harrowing. The clover may be pastured during the first season, but should not be cropped too closely during the driest part of the summer. This is becoming quite a popular method in the Willamette Valley and very satisfactory stands are secured, but the use of the land is almost lost the first year.

Clover may be sown alone also in the late summer or early autumn. Although this method is seldom used it is probably one of the most satisfactory ways of sowing clover west of the Cascade Mountains. If sown with grain in the fall, clover does not make a crop the next year, but if sown alone in the late summer a full crop is secured the next summer. It is essential, however, that the seeding be done early, for if sown in the late fall it is liable to be winterkilled. Only crops, then, that can be removed early should precede clover sown in this way.

(5) *Clover with rape.*—Sowing clover with rape is a very successful and popular method with many farmers who are engaged in raising sheep and goats. With the land prepared as indicated for sowing clover alone in the spring, from 10 to 12 pounds of clover seed and from 2 to 4 pounds of rape seed per acre are sown broadcast about the 1st of May and covered with a harrow. If the ground is rough and cloddy, it should be finished with a roller. If this mixture is sown on a thoroughly pulverized and compact seed bed, the rape develops rapidly and furnishes excellent pasture for sheep, goats, calves, or swine in from six to eight weeks. The tramping of the animals while feeding during the summer, principally on the rape, forms a dust mulch on the surface of the ground. In this way soil moisture is retained for the use of the clover during the dry summer season. If a hay crop is desired the second season, the rape is killed by pasturing it closely with sheep during the late fall or winter. Sheep eat off the crowns of the plants close to the ground and the rape then dies. If the rape is not killed it will go to seed the next summer, and the stalks will give some trouble in the hay. If the clover is not cropped too closely the first summer, this method gives an excellent stand.

Failures occur frequently, especially in the Willamette Valley, when clover is sown by any one of the first three methods described. With rich, moist soil of good texture and with frequent rains during the summer these methods are usually successful. But with soils that are inclined to puddle and dry out quickly—soils that have produced grain crops exclusively for a number of years—they often give poor results. Under such conditions the grain shades the clover too much, and robs it of the moisture necessary to carry it through the first summer.

THE SEED CROP.

Since the first crop of clover is seldom used for se hay or ensilage about the 1st of June to enable the make a good growth before the dry season begins. In: the first crop for hay or ensilage, clover is sometimes late in May, and the first crop is then used for seed. first crop, however, the second one comes on more ev the first is pastured.

When the heads of the seed crop are pretty well drie brown in color the clover is cut with a self-raking re mower with a buncher attachment. Bunches of the : nary wheat bundle are dropped in rows. When the enough to powder when rubbed in the hands five or : thrown together by hand or bunched with a hayrake when damp with dew. The thrashing is done when clover huller, and the clover is hauled to the ma bottomed racks in order that the shattered seed may r

ALSIKE CLOVER.

Alsike clover (*Trifolium hybridum*) has a much adaptability in western Oregon and western Washi clover. It thrives not only on soil adapted to the clays and well-drained soils—but also on lowland bottoms, and many soils too wet and cold to grow ı stems are much finer and more recumbent than thos and its leaves are not so numerous. The yield of t very satisfactory, but it is disposed to make but litt a crop has fully matured for hay. If cut early, hov to make a very satisfactory second growth. A delay days in the time of cutting the first crop makes : difference in the growth of the second.

Alsike clover makes a very good quality of hay an to sow with timothy, since these two crops mature at It is a perennial, stands grazing well, and seems t susceptible to the attacks of the clover root borer tha Since alsike clover is so nearly the equal of red clover way it should be given a thorough trial in all locali Cascade Mountains where red clover may have failed

From what has been said it is evident that alsike clo adapted for sowing on land that is too cold and wet in mixtures for permanent pastures, and on forest b slashings that are to be used for pasture for several y

The seed of alsike clover is quite small and 5 or 6 ı will be found sufficient when it is sown alone. With

all that has been said regarding the seeding of red clover applies equally well to alsike clover.

COMMON VETCH.

The common vetch (*Vicia sativa*) is perfectly adapted to conditions west of the Cascade Mountains in Oregon and Washington and thrives even on very poor soil. It has been grown in the Willamette Valley for many years, and is rapidly replacing red clover in many localities. It is an annual legume of great value as a nitrogen gatherer, as a green manure, and as a soiling, hay, and pasture plant. It is also a very valuable cover crop in orchards when sown in the early fall. It makes excellent ensilage, and dairy cattle prefer the hay to that of red clover. The yield of cured hay is from 1½ to 4 tons per acre. A seed crop yields from 15 to 30 bushels per acre, the yield depending quite largely upon the efficiency with which the seed is saved. A bushel of clean seed weighs a little more than 60 pounds.

METHODS OF SOWING.

Common vetch stands the winters admirably in western Oregon and western Washington, and is sown in the autumn from the last of August to the last of November. It is sown also in the early spring, but fall seeding usually gives the largest yields. The stems of this vetch are not strong, and heavy crops are inclined to flatten out on the ground. When in this fallen condition it soon begins to mold and is very difficult to harvest. To furnish support for it and keep it up off the ground a bushel of oats, wheat, or rye, and a bushel of vetch per acre are usually sown together. Oat hay, especially for dairy purposes, is usually preferred to that of wheat or rye, and for this reason oats are usually sown with vetch, winter oats being sown in the fall and spring oats in the spring. It is a common practice with vetch growers to sow winter oats and vetch broadcast in the early fall on land that has raised a spring crop and to cover the seed with a disk harrow. If the land is loose and easily worked, this method gives good results, but like most other crops vetch gives much better yields if sown on a well-prepared seed bed. If the ground is packed, or if the seeding is done in the spring, the land is usually plowed and a good seed bed prepared.

SOILING.

Sown with rye the last of August or early in September, common vetch should be ready for soiling, i. e., feeding green, from April 15 to May 1; sown with winter oats or wheat October 1, it should be ready about May 1; sown with winter oats or wheat in the late fall, it should be ready about June 1; sown with oats in February, it

should be ready about June 15. When cut in the early spring for soiling a second crop may be cut or pastured, or the land may be plowed and planted to some other crop.

THE HAY CROP.

Since fall-sown vetch matures for hay in June and rains are not infrequent at this season of the year it is quite a common practice to pasture it in the early spring—March and April—to keep the growth from becoming so heavy that it will fall before it is cut and to retard its development so that haymaking will occur after the rains are over. If the crop is heavy and falls during bad weather it is best to make ensilage of it immediately.

When the seeds are just appearing in the first pods is usually considered the best time to cut vetch for hay. Some cut it earlier than this, while others allow the first seeds to become pretty well matured. If the crop is not too heavy it may be handled in the ordinary way, but it should be put into cocks before the leaves are dry enough to be broken off during the handling. When very heavy it falls more or less, and usually in some prevailing direction. When in this fallen condition the rear of the sickle bar of the mower is usually raised and the guards tilted down. Sometimes a man follows the mower with a strong pitchfork and when the vetch clogs he sticks the tines of the fork into the ground just behind the sickle bar and pulls the vetch loose.

Others cut vetch in but one direction, the opposite way from that in which it is leaning, driving the mower back idle each trip. Men with forks throw each swath out as it is cut, so that the mower can get through without the vetch clogging on the sickle bar. Another way is to cut a swath and with forks roll it on the uncut vetch; cut another swath and roll the two cut swaths on the uncut vetch; cut again and roll out the three cut swaths. This process forms windrows of three swaths each. (See fig. 1.)

With the vetch fallen in one prevailing direction, others cut one way only, driving the mower in such manner that the fallen vetch will point forward and away from the direction driven at an angle of about 45°. A little experience will enable one to determine the proper angle. When the cutting of a swath is finished the sickle bar is raised and the mower thrown out of gear and driven back on the swath just cut to mash it down and make a path for the shoe of the sickle bar with the wheel of the mower. With the rear of the sickle bar raised, the guards tilted down, the vetch lying in the direction indicated, and the last cut swath lapping up on the uncut vetch and mashed down by driving the empty mower back over it, the inner wheel of the mower, as the next swath is being cut, runs

upon the swath just cut and holds it so that the shoe of the sickle bar slips over with little or no clogging. In this way the swath upon which the wheels of the mower are running is cut in two again and another clean swath is also cut at the same time. Cutting each swath in two twice makes the handling of the hay much easier. After being cut the hay may be cured and handled in the usual way.

THE SEED CROP.

It is very difficult to separate the seeds of wheat or rye from vetch seed, while those of oats and vetch can be separated reasonably well. For a seed crop that is intended for market, therefore, oats and vetch

FIG. 1.—A common method of cutting tangled vetch. The first swath cut is rolled on the uncut vetch; after the mower passes again, the double swath is rolled on the uncut vetch; when the mower has cut under this, the triple swath is rolled outward.

are usually sown together in the early fall—about a bushel of each per acre. In the spring they are usually pastured until April to keep the growth from becoming so rank that it will fall. The vetch then matures in July. The seed matures very unevenly; the pods burst open when overripe and exposed to the sun, and much of the seed may be lost in this way. The best seed is always produced in the lower pods and the seed crop is usually cut when these pods are turning brown and before they have begun to drop their seed.

If the crop stands up well and is not too heavy it is cut with a binder and shocked immediately. From 12 to 15 bundles are put in the bottom of the shock and other bundles built on top of this

again, letting the butts of the upper bu of the lower ones. Other bundles ar covering all of the seed pods possible. of a great deal of seed, for the pods d not exposed to the sun.

If strictly pure seed is desired, vetc the rate of 100 to 120 pounds per acre. sonably well. If the seed crop is too h mower. With pitchforks the first cut vetch; another swath is then cut and the uncut vetch. When the third swa are rolled out. This forms windrows then placed in large cocks immediatel little exposure to the sun as is possible. cocking largely prevents the loss of and raked in the usual way the wheel the rake, and the tramping of the horse As soon as the vetch is dry it should b an ordinary thrashing machine, hauli with tight bottoms or with canvas spre shattered seed. In thrashing, the con having no teeth used instead. The m down and plenty of wind turned on. vetch for seed would greatly increase cut with a mower. The pods on the s and burst before the centers of the co way a great deal of seed is lost. The the surface of the cock from the dire the whole cock to dry more evenly. (on p. 11.)

In growing a seed crop of vetch c ground by the bursting of the pods. plowed under, much of it will be co The amount of oil in the seed is suc ground for years without decaying, a near the surface by subsequent plowin a pest in wheat that is grown for ma seed crop of vetch may be prepared f and vetch broadcast in the fall, witho with a disk harrow. Cut the oats an and pasture the second growth close e maturing. Grow a cultivated crop th then be ready for winter wheat.

PEARL VETCH.

Pearl vetch (*Vicia sativa alba*) has been grown in the Willamette Valley for a number of years, but is comparatively unknown except in the vicinity of New Era, Oreg. It is so much like the common vetch (*Vicia sativa*) that they can not be distinguished except by the color of the seed. The common vetch has a dark-colored, mottled seed, while the seed of pearl vetch is a light salmon color, with a pearly luster. The uses and values of these two plants seem to be identical. with the exception that the seed of pearl vetch, it is claimed, is a good table vegetable, being used particularly in making soup. Its seed probably also makes better feed when chopped. What has been said regarding the uses, culture, and handling of the common vetch applies equally well to pearl vetch.

FIELD PEAS.

Field peas (*Pisum arvense*) are well adapted to the conditions of western Oregon and western Washington. They do well on a large variety of soils, but are especially adapted to clay soils and alluvial bottoms. They are grown for grain, hay, ensilage, and soiling. Peas are nutritious, and the hay and ensilage are eaten with relish by most kinds of stock. When grown for hay about 2 bushels of peas and 2 bushels of oats per acre are sown together as early in the spring as the condition of the ground will permit. When sown at the same time the oats often choke out the peas. This may be largely avoided by sowing the peas first, preferably with a drill, since the seed is difficult to cover, and when they have sprouts on them about 2 inches long drill in the oats. This will give the peas the start and they will hold their own much better. If sown broadcast they should be well covered with a disk harrow. Peas should be cut for hay when the seeds in the first pods are just ready for table use. Sown in the early spring they mature for hay from the 1st to the 15th of July. The yield is from 1½ to 4 tons of hay per acre. When harvested for seed the yield is usually from 25 to 30 bushels per acre. Peas are often sown alone and harvested when mature by swine turned into the field.

The pea weevil often does considerable damage to the pea crop, especially when grown for seed. When sown late, peas suffer much more from the ravages of this pest than they do when sown early. Since they stand considerable frost they should be sown as early in the spring as the season will permit. Of late years peas fail in some localities from other causes than the weevil. They assume a pale, sickly appearance and the yield and quality of the hay are very unsatisfactory. In localities where this happens common vetch and pearl

vetch should be grown instead of peas, for they are sure crops and are equal or even superior to peas in practically every way as a forage plant.

ALFALFA.

At the present time the growing of alfalfa (*Medicago sativa*) west of the Cascade Mountains is only in the experimental stage. Small areas are to be found in various places, some of which are doing reasonably well. Most of these have not been planted long enough and have not been studied sufficiently to justify definite conclusions as to the future usefulness of alfalfa in this region. There are many localities with well-drained soils, however, in which it will unquestionably succeed if given proper treatment. In regions in which the rainfall is as great as it is at certain seasons west of the Cascade Mountains, alfalfa requires a loose, permeable subsoil, and seems to thrive best on the sandy loams along the water courses. The best alfalfa fields noticed were on the sandy alluvial soils on the Willamette and Columbia rivers. The water table of land selected for alfalfa should be at least 4 feet below the surface, and the land should not be subject to overflow. Alfalfa will stand considerable flooding, provided the water is running, but it is usually destroyed if stationary water covers it for a few days.

There are two important difficulties to be overcome in the successful production of alfalfa in this region. In the first place bluegrass, English rye-grass, Italian rye-grass, velvet grass, couch-grass, and many other grasses and weeds have a strong tendency to crowd out the alfalfa. This difficulty is largely overcome by eradicating these plants, so far as possible, before the seeding is done. Thorough disking and harrowing at a time when the alfalfa has made but little growth, or just after cutting a crop of hay, tends to keep it vigorous and holds the weeds and grasses in check. The disk harrow should be weighted to make it cut deep and should be set about as straight as possible, so as not to cut off the crowns of the alfalfa plants. Although these grasses, when growing with alfalfa, actually decrease the total amount of forage produced, they also decrease the danger of bloating when the field is pastured by sheep, goats, or cattle. In fact, grasses are frequently sown with alfalfa for this purpose. Secondly, the first and last crops of alfalfa mature at seasons of the year when it is very difficult to make hay on account of the damp weather. This objection is obviated by using the first and third cuttings for ensilage, soiling, or pasture.

METHODS OF SOWING.

This must be governed largely by local conditions. Land that is naturally well drained or that is tiled at least 3 feet deep should be selected for this crop. If barnyard manure is available, put on from 15 to 20 tons per acre in the fall

and plow it under 8 to 10 inches deep. In the spring, when the land is in good working condition, cut it up thoroughly with a disk harrow and work it down fine. Let it lie for a week or ten days; then give a good harrowing so as to destroy all weeds. Sow about 15 pounds of clean seed per acre and cover with a harrow. If the soil is inclined to be dry, finish with a roller. About the time the seed is sown, put on 75 to 100 pounds of land plaster to the acre.[a]

INOCULATION.

The failure of alfalfa west of the Cascade Mountains is frequently due to the lack of nodule-forming bacteria in the soil. If the land to be sown has never grown alfalfa before, it is the safest plan to artificially introduce these organisms. This may be done in two ways:

(1) From 300 to 500 pounds of soil, the more the better, may be hauled from a field that has recently produced alfalfa with nodules on the roots, and scattered evenly over the surface of the new field. This should be done just before the alfalfa seed is sown and the soil should be thoroughly mixed with that of the new field by harrowing or disking. It is quite expensive to inoculate large fields in this way and there is always a possibility of transferring plant diseases from one field to another.

Of scarcely less importance is the danger of disseminating noxious weeds and insect pests through this plan of inoculating by means of natural soils. Even though weeds may not have been serious in the first field, the great number of dormant seeds requiring but a slight change in surroundings to produce germination is always a menace. If soil is to be used, however, whether obtained from near-by fields or shipped long distances, the evidence should be clear that the soil is free from the objections mentioned above.[b]

(2) Pure cultures of the proper bacteria may be used. The Bureau of Plant Industry of the United States Department of Agriculture has isolated the different organisms for the different legumes, is growing them in pure cultures, and furnishes them to farmers whose soil conditions seem to indicate that inoculation is necessary.

Those desiring inoculating material should write to Soil Bacteriology Investigations, Bureau of Plant Industry, Washington, D. C., for an application blank. To avoid delays, requests should be on file several weeks before the material is to be used.

Should weeds tend to crowd out the alfalfa during the first year, they should be mown often enough to hold them in check. The cutter bar of the mower should be set about 5 inches high in order that the young alfalfa plants may not be cut too closely. If the crop mowed would be sufficient when dry to make a third of a ton or more of hay (and dried weeds) to the acre, which it usually will be in spots, it should be removed from the field; if less than this it may be permitted to lie where it is cut.

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[a] Dr. James Withycombe, in Bulletin 76, Oregon Experiment Station.

[b] Farmers' Bulletin No. 240, U. S. Dept. of Agriculture.

The leaves and stems of alfalfa sometimes turn yellow, and the crop then assumes a very unthrifty appearance. When this condition begins to manifest itself the field should be cut immediately, even though the growth be very small. This will tend to invigorate the plants and keep them in a growing condition. If the growth is sufficient the first season, it may be used for either hay or pasture, but under no circumstances should it be closely pastured the first year.

In the moist climate west of the Cascade Mountains it frequently happens that alfalfa sends up young shoots from the crown of the plants before the first growth begins to bloom. When this occurs it should be cut at once; otherwise the first crop soon begins to deteriorate and the second growth will be seriously stunted. In this region it is very essential, therefore, to watch alfalfa closely and cut it as soon as these young shoots begin to appear.

Alfalfa is not a satisfactory pasture crop for cattle or sheep because of its tendency to produce bloat in these animals when they are allowed to graze on it, but for horses and hogs, particularly hogs, there is no better pasture.

TIMOTHY.

Timothy (*Phleum pratense*) is the standard grass in Oregon and Washington west of the Cascade Mountains. It is shallow rooted and naturally adapted to moist lands. But the abundant rainfall of this region, distributed as it is through so many months of the year, makes it possible for it to succeed on practically all classes of soils except the sands and gravels. There are individual farmers who like other grasses better, but timothy is the one grass that is universally known and grown. It has been the standard market hay so long and has so many valuable characteristics that it will require years for any other grass, even with superior qualities, to become as popular as timothy in this region.

There are many reasons why timothy enjoys this popularity. It has the best seed habits of any of our cultivated grasses. The seed is usually cheap, has a very high percentage of germination when properly matured, is easily harvested, and retains its vitality remarkably well. The hay is easily cured, stands handling well, and is relished by all kinds of stock. Unlike many other grasses, a few days' delay in the time of cutting makes but little difference in the quality of the hay—a very important point in a region where showers are not infrequent during the haying season.

West of the Cascade Mountains timothy is most frequently grown with red clover. It is sometimes sown in the fall with winter wheat and the clover added in the spring, during February or March, when the ground is thawing and freezing. Another method is to prepare the ground in the spring and sow the timothy and clover with or

without a nurse crop. Still another way is to sow the clover in the spring with a nurse crop and in September, after the grain has been harvested, sow the timothy on the stubble. When sown with a nurse crop, timothy and clover are shaded too much, especially if the nurse crop is allowed to mature for grain, and unsatisfactory stands are often obtained in this way. Perhaps the most satisfactory way of sowing both timothy and clover is to sow them without a nurse crop in the late summer or early fall on land that is as free as possible from weeds. Good stands are secured in this way, and they give excellent yields the first year. Timothy is two or three weeks later than red clover, and when they are grown together for hay either the timothy must be cut a little immature or the clover allowed to become too ripe. For this reason some other grasses are better suited than timothy for sowing with red clover. When sown alone from 6 to 10 pounds of timothy seed per acre are sufficient. For a seed crop timothy yields much better when the stand is comparatively thin. A much finer quality of hay is produced when it is thick. It is the general rule to cut timothy for hay just at the end of the blooming period. Cattle prefer the hay when cut at this stage, while horses seem to relish it better if it is a little more mature.

THE RYE-GRASSES.

English rye-grass (*Lolium perenne*) and Italian rye-grass (*Lolium italicum*) are more popular on the Pacific coast west of the Cascade Mountains than in any other part of the United States. The moist, mild climate of this region is well adapted to their growth, and they are very popular with the comparatively few farmers who grow them. Stock seem to prefer them to all other grasses, and the herbage they produce is certainly of a very fine quality. The rye-grasses form a close sod and stand cropping and tramping well, but they do not yield so well as some other grasses. They mature early and are well suited to sow with red clover. They are especially adapted to low, moist soils, and when grown under favorable circumstances they may be cut two or three times during a season. Italian rye-grass is practically an annual. The plants do not all die at the end of the first year, but they amount to but little after the first season. Although usually considered a perennial, English rye-grass is short-lived and is very little better than Italian rye-grass in this respect. In England, where these grasses occupy a similar position in agriculture to that of timothy in the United States, it is a common practice to allow seed to mature before they are cut for hay. In this way they reseed themselves and last from year to year. It is claimed also that this is a safe thing to do so far as the quality of the hay is concerned.

The seed of these grasses is usually of good quality and germinates well. It weighs from 14 to 20 pounds per bushel. It may be sown in the spring, but early fall seeding gives the best results in this region. When sown alone from 25 to 40 pounds of seed per acre should give satisfactory stands. The rye-grasses sown with clover make excellent silage.

ORCHARD GRASS.

Orchard grass (*Dactylis glomerata*) thrives remarkably well on all tillable soils west of the Cascade Mountains, except those that are very wet. It is the earliest grass to start to grow in the spring; it revives quickly after it is cropped by stock or cut for hay, especially if the soil is moist; it remains green during the summer and fall, and is relished fairly well by all kinds of stock; it stands grazing and tramping much better than timothy, and lasts for a number of years when given proper care. It is, therefore, eminently adapted for pasture purposes and should form an important part of every permanent pasture mixture.

Orchard grass makes an excellent quality of hay if cut before or just after the blooming period. If the cutting is delayed but a few days beyond this period orchard grass has a strong tendency to become woody, and the hay is then of poor quality. It ripens with red clover, and under favorable circumstances it may be cut twice during a season. It is, therefore, especially well fitted for sowing with red clover when intended for hay. It grows in bunches and does not make a smooth sod; for this reason it is seldom sown alone. Orchard grass is a little early, and is often ready to cut before good haying weather has begun. This fact and its tendency to become woody immediately after blooming are the chief drawbacks to its culture west of the Cascade Mountains. Its earliness is an advantage, however, when it is used for ensilage or soiling.

The seed habits of orchard grass are very satisfactory, and the yield is from 15 to 18 bushels of seed per acre. The seed weighs from 14 to 18 pounds per bushel. When sown alone 20 to 25 pounds of seed per acre will be sufficient. It is sown either in the fall or spring. If sown in the early fall, without a nurse crop, it should make an excellent crop the next year.

MEADOW FESCUE.

Although meadow fescue (*Festuca pratensis*) is grown but little west of the Cascade Mountains, it is highly prized by those who know it. Like orchard grass, it is adapted to practically all of the tillable soils of the region except those that are gravelly or very wet. It is a perennial; lasts much better than timothy; is relished by all

kinds of stock; makes a good quality of hay; and, when once established, stands tramping and grazing well. It does not begin to grow so early in the spring as orchard grass, but remains green during the summer and makes a good growth during the fall. It is especially adapted to a place in meadow and pasture mixtures that are to occupy the land for a number of years. One of the leading dairymen of the Willamette Valley sows the following mixture in the spring: Meadow fescue, 10 pounds; English rye-grass, 10 pounds; timothy, 4 pounds; red clover, 4 pounds, and alsike clover, 2 pounds. This mixture is used for hay for two years, and then for pasture three years. Of the grasses in this mixture, meadow fescue is his favorite.

Meadow fescue may be sown in the early fall or spring. When sown alone, from 15 to 20 pounds per acre of the best seed should be used. If the quality of the seed is doubtful, sow more. Kansas farmers who grow their own seed sow only 12 to 15 pounds per acre.

VELVET GRASS.

The only part of the United States in which velvet grass occurs to an extent worthy of notice is on the Pacific coast west of the Cascade Mountains, from northern California to the Canadian line. In that section it is indifferently called velvet grass and mesquite. The latter name should never be applied to this grass, as it is used for several other very different grasses in the Southwest.

It is generally regarded as a pest on the Pacific coast, particularly on lands that are very wet in winter and very dry in summer. This is especially the case with both sandy and peaty soils on the coast. It is not utilized for feed in many localities, but on the extensive areas of sandy land around the mouth of the Columbia River and at one or two points inland it is the chief reliance, both for hay and pasture. It yields ordinarily about half a ton of hay per acre. The hay is remarkable for its lightness, a ton of it being much more bulky than a like weight of other kinds of hay. Horses nearly starve before they acquire a taste for velvet grass, but when the taste is once acquired they thrive upon it remarkably well, showing that it is highly nutritious. The whole plant is covered by a growth of wool-like hairs, from which fact the name is derived. It is unworthy of attention except on the classes of soils above mentioned. On these soils it drives out all other grasses.[a]

Velvet grass (*Holcus lanatus*) is frequently a pest in meadows. The seed matures very early, is light, and shatters readily. When clover, rye-grass, and timothy are ready to cut for hay the seed of velvet grass is usually mature enough to germinate. The wind blows the seed, and wherever the hay is hauled or handled the seed is scattered. If a meadow that is infested with velvet grass is cut a little early for either hay or ensilage, the seed can not be spread in this way. Velvet grass gives no trouble in the second crop of clover. Fence rows and waste places beside meadows should be mown early

[a] W. J. Spillman, in "Farm Grasses of the United States."

enough to prevent seed from maturing. If these precautions are taken the grass can be prevented from becoming very troublesome.

To eradicate velvet grass cut it early, before the seed is ripe, generally from the 10th to the 20th of June. About the 1st of July give it a thorough but shallow disking. Repeat the shallow disking every week until the 1st of August and then spring-tooth and disk again. This shallow cultivation during the driest season will kill the roots and leave the ground with a very fine mulch on top and plenty of moisture in the subsoil. The land may then be reseeded to clover or planted to any crop desired.[a]

INDIAN CORN.

The climatic conditions of western Oregon and western Washington are not well adapted to the growing of corn (*Zea mays*). The nights are too cool for its best development, and unless very early varieties are grown difficulty is often experienced in bringing it to maturity. Nevertheless corn fills an important place in the cropping systems of this region, particularly on dairy farms; i. e., for ensilage and for feeding green during August, September, and October. While it may be impracticable to grow corn for the grain, it is possible by selecting very early varieties and using seed grown near by to grow a good quality of ensilage corn. The aim should be to grow those varieties that reach as near maturity and yield as much grain as possible. The large southern varieties produce very little grain here, and are so immature when put into the silo at the end of the season that too much acid develops.

The following table gives the quantity of water and dry matter in corn at different stages of growth, as determined by the New York (Geneva) Agricultural Experiment Station:

Water and dry matter in corn at different periods after tasseling.

Date of cutting.	Stage of growth.	Corn per acre.	Water per acre.	Dry matter per acre.
		Tons.	*Tons.*	*Tons.*
July 30	Fully tasseled	9.0	8.2	0.8
Aug. 9	Fully silked	12.9	11.3	1.5
Aug. 21	Kernels watery to full milk	16.3	14.0	2.3
Sept. 7	Kernels glazing	16.1	12.5	3.6
Sept. 23	Ripe	14.2	10.2	4.0

This table is very interesting. The last column shows the dry matter of corn at different stages of growth. Ripe corn yields five times as much dry matter per acre as corn that is fully tasseled, two and two-thirds times as much as corn fully silked, and nearly one and three-fourths times as much as corn in the milk; hence, the importance of growing corn for ensilage that will mature. The

[a] Letter from W. H. Kaufman, Bellingham, Wash.

table also shows the great waste in feeding corn green instead of letting it mature properly and making it into ensilage.

In order that ensilage may keep well, corn should be cut about the time the kernels are well glazed and dented. If it is cut too green, as stated, too much acid develops; if cut too ripe it does not settle properly and the air is not sufficiently excluded to prevent spoiling. The ripest corn should always be cut first and placed in the bottom of the silo, because the great pressure near the bottom will tend to exclude the air.

If planted on rich, mellow, well-drained land between the middle of May and the first of June, corn should be ready for feeding green from about the 1st to the 15th of August. As previously stated early varieties should be planted, and seed grown west of the Cascade Mountains succeeds better than eastern seed.

RAPE.

Rape (*Brassica napus*) has been grown in the Willamette Valley with excellent results for twenty years. It is a succulent, nutritious forage plant, admirably adapted to the moist, mild climate of the Pacific coast. It stands considerable freezing, and is seldom winter-killed west of the Cascade Mountains. It does best on deep, warm, well-manured loamy soils. It succeeds well also on peaty soils, but is not adapted to very light sandy or heavy clay soils. It is a heavy feeder, and must not be expected to succeed on poor, worn-out land.

Rape is an excellent crop for pasture or soiling, i. e., for cutting and feeding green for hogs, sheep, goats, and poultry. Fed to dairy cows it causes a large flow of milk, but to avoid tainting the milk it should be fed immediately after milking, at the rate of 30 to 50 pounds per day, in two feeds. On account of danger of bloating, sheep, goats, and cattle should never be turned on rape for the first time when they are hungry, or when the rape is wet with dew or rain. They should have plenty of something else to eat first, and plenty of salt at all times. It is a good plan to give them access to hay or a grass pasture to prevent overloading on rape. When sheep have become accustomed to it they may be left on it continually with but little danger.

Rape is grown and utilized west of the Cascade Mountains in several different ways:

(1) When grown for early summer use, the largest yields and the best results are secured by making a succession of plantings at intervals of two or three weeks, beginning in the early spring as soon as the ground can be put into perfect tilth. The ground should be well manured and the seed planted in drills 24 to 36 inches apart at the rate of about 2 pounds per acre. A common garden drill may be used

in planting small areas, but for larger fields a grain drill, with some of the feed hoppers closed to make the rows the desired distance apart, answers the purpose best. As soon as the plants are sufficiently large they should be cultivated often enough to control the weeds and keep the soil in good tilth. The cultivation will retain the soil moisture and tend to keep the plants growing vigorously. Unless cultivated during the dry portion of summer, growth almost ceases until the fall rains come. Rape grown in this way may be used either for pasture or for soiling.

When rape is used for soiling purposes it should be cut at least 5 inches high, so that the plants will have a chance to grow again. In from six to eight weeks after planting it should be large enough to cut; by making a succession of plantings green, succulent feed should be on hand throughout the summer. If rape is used for pasture, the best results will be secured by having a number of small fields which are pastured alternately. It may be fed in this way also by means of movable fences. Rape should be from 12 to 14 inches high before it is used for pasture, and hogs should be prevented from rooting while in the field. When rape is removed by cutting or pasturing closely, the evaporation of soil moisture is rapid, and it should be cultivated as soon as possible if a second growth is desired. If sown in drills, stock will walk between the rows while feeding, and much less will be broken down and destroyed than if they were feeding upon rape that was sown broadcast. A larger yield is also secured by planting rape in rows and cultivating it.

(2) Another favorite way of growing rape is to sow it broadcast at intervals in the spring. The land is plowed and thoroughly worked in the early spring, as soon as it is in good working condition, and then allowed to lie until the seeding is done. Just before each piece is sown the ground is cultivated thoroughly again and from 3 to 4 pounds of seed sown and covered with a harrow or cultivator. Instead of sowing the seed broadcast it is sometimes planted with a common grain drill. Rape sown the 1st of May should be ready for pasture the 1st of July; if sown the 1st of June, it should be ready for pasture by the 1st of August. Grown in this way rape makes excellent pasture during the summer, fall, and early winter.

(3) Another method of raising rape that is popular with many farmers, especially those who raise sheep or goats, is to grow it with clover. The method of doing this has already been fully described in the discussion of red clover (page 16).

(4) Rape is sometimes sown with oats in the spring on a thoroughly prepared seed bed. The oats are used for either hay or grain. The rape grows but little until the early fall rains come, after which it is soon ready for pasture. From 2 to 4 pounds of rape seed per acre are sufficient when sown in this way.

(5) From 3 to 4 pounds of rape seed per acre are also sown with corn just before the last cultivation. The seed is then covered by the cultivator and the rape comes on and makes good pasture as soon as the corn is harvested. It may also be sown with potatoes, but it does not succeed so well with them as with corn, for the digging of the potatoes destroys much of the rape. Sown after early potatoes are dug, it gives good pasture during the late fall and early winter.

THE SEED CROP.

Good rape seed is now produced in the Willamette Valley and the region about Puget Sound, and there is no reason why farmers should not produce their own seed. Rape is a biennial and does not produce seed when sown in the spring until the second year. If sown in September or October it matures seed the following June. Rape may be cross-fertilized by kale, cauliflower, and other closely related plants. It is believed to cross also with wild mustard and wild turnips; hence none of these plants should be allowed to grow near rape that is intended for seed.

For seed, rape should be sown alone, and it is very desirable to have in it drills in order to cultivate it and keep it free from the plants mentioned. Rape that is planted in drills in the spring may be used for soiling during the summer and fall, carried through the winter, and used for a seed crop the second season. If sown entirely for a seed crop, it may be planted in the fall—September or October—after some early crop has been removed. To retard development of the plants so that the seed will mature after the late spring rains are over, it should be pastured or cut back about the last of April or the first of May. If ripe rape gets wet the seed shatters very readily, and the retardation of the development of the crop is often very necessary in order to have good weather for harvesting the seed.

Rape should be cut for seed when the first seeds are turning brown. It may be cut with a binder or a self-raking reaper. It should be shocked in such manner that it will dry out quickly. Birds destroy considerable of the seed; hence it should be thrashed as soon as dry. If the crop is not too extensive a man with a team and sled may drive from shock to shock and thrash it by hand. If a thrashing machine is used, it should be hauled to the machine in tight-bottomed racks, or canvas should be spread over the racks to catch the shattered seed. It is said that a yield of 1,000 pounds of seed to the acre is not unusual in the Willamette Valley.

Seed may be purchased of local seedsmen. When buying seed, however, one should always call for Dwarf Essex rape. There are a number of varieties of rape, some of which are annuals and are grown only for bird seed. If these annuals are sown in the spring

they produce seed the same year and are liable to become serious pests when once introduced. Complaint has been made that Dwarf Essex rape becomes a weed, but it is easily controlled. It does not produce seed until the second season, and if plowed under during the fall, winter, or spring no seed can be produced.

THOUSAND-HEADED KALE.

Thousand-headed kale (*Brassica oleracea*) has been grown in the Willamette Valley for 27 years. It attracted little attention among the dairymen until recent years, but is now rapidly becoming a very popular fall and winter soiling crop. It stands the mild winters

FIG. 2.—A field of thousand-headed kale on Martins Island, near Kalama, Wash. A valuable winter soiling crop, available from October 1 to April 1.

west of the Cascade Mountains admirably and is hauled from the field and fed as needed. It does not head up like cabbage, and the name "thousand-headed" is given it on account of the numerous branches the plants have when given plenty of room. It is very much like rape, but the plants are much taller and the leaves are longer and broader. A field of this crop is shown in figure 2. It is claimed that kale will yield 30 to 40 tons of green feed per acre when grown under favorable conditions.

Kale is used for table greens, but its chief use on the Pacific coast is for feeding green to dairy cows from October to April, for which it is highly prized. It would undoubtedly be an excellent winter

feed also for hogs and poultry. It does best on well-manured. deep. rich loams and sandy soils. The only objection to the use of kale is the difficulty of getting it out of the field when the ground is wet and muddy. For this reason well-drained land should be selected upon which to plant this crop.

METHODS OF SOWING.

For. fall and winter use, kale is usually sown in drills on well-prepared and well-drained soil as soon after the 15th of March as the season will permit. This furnishes plants for transplanting in June and July. The land used for transplanting is well manured and plowed two or three times between the 1st of March and the 1st of June. With the land in perfect tilth it is plowed again with a 12-inch plow about the 1st of June and the young kale plants dropped into every third furrow about 2½ to 3 feet apart. This places about one plant on every square yard. The roots of the plants are placed where the next furrow covers them, leaving the tops uncovered. The plants that are plowed in during the day in this way are rolled in the evening of the same day to pack the ground. Two or three cultivations are all that can usually be given, for the plants will soon touch in the row if they do well. Any plants that fail to grow may be replaced by hand. Some growers prefer to plant the seed in hills, and when the plants are large enough thin them to one plant in a hill. Others put kale out just as cabbage is usually transplanted, instead of plowing it in. The time of transplanting must be determined by the size of the plants and the condition of the land. If the land is wet and subject to overflow the transplanting may be delayed until during July. If the land is well drained and the plants are large enough it may be done before the 1st of June. In transplanting, enough plants may be left for a stand on the land where the seedlings are grown.

FEEDING.

As previously stated, kale stands in the field during the winter and is hauled in and fed green as needed from about the 1st of October to the 1st of April. If the growth is forced in the early spring it can be fed much earlier than the 1st of October. To avoid tainting the milk, kale is fed just after milking, at the rate of 25 to 50 pounds per day, in two feeds. Some let it wilt before feeding. Enough may be hauled in at a time to last four or five days. It should not be thrown into heaps and allowed to heat. Neither should it be fed when frozen. On the approach of freezing weather a supply sufficient to last several days may be placed in the barn.

To haul kale from the field during wet weather it is best to wear a gum coat and gum boots. The plants can then be cut off at the sur-

face of the ground with an ax, thrown into piles, and loaded on a wagon with a pitchfork without serious inconvenience to the worker.

Kale grows a great deal during the fall and winter, and much is lost by feeding the whole plant in the early part of the feeding season. By using only the lower leaves it is possible to begin feeding quite early without stopping the growth of the plants. With the thumb and fingers of the hand extended, one can break off all of the lower leaves of a large plant with three or four downward strokes of the hand. This is not practicable, however, during damp weather, for the leaves would be too wet to handle in this manner.

THE SEED CROP.

An excellent quality of kale seed is produced in the Willamette Valley. Like rape, it is a biennial and does not produce seed until the second year. Richard Scott, a dairyman of the Willamette Valley, has grown kale for twenty-seven years. He produces seed about as follows: There is considerable variation in the types of individual plants. During the first year plants with many rather narrow leaves that begin spreading from near the surface of the ground are selected. This type of plant yields more and stands freezing better than a plant the stem of which is bare for some distance above the ground. These selected plants are transplanted in February in some isolated place to prevent cross-fertilization by undesirable kale plants, rape, cauliflower, and other closely related plants. It is believed that kale crosses with wild mustard and wild turnip; hence none of these plants should be allowed to grow near kale that is intended for seed. The seed crop is cut when the first seeds are turning brown. If the crop is small, it is usually thrashed by hand. A large crop may be handled the same as a seed crop of rape. Birds are fond of the seed, and for this reason it should remain in the field only until dry.

ROOT CROPS.

Since the soil requirements and the methods of culture of mangel-wurzels (*Beta vulgaris* var. *macrorhiza*), carrots (*Daucus carota*), and ruta-bagas (*Brassica campestris*) are very similar, they will be treated collectively. Like rape and thousand-headed kale, they succeed best where the weather is moist and cool. Hence their eminent adaptation to western Oregon and Washington. In this region the yield of these crops is enormous, the ordinary yield being from 20 to 35 tons per acre, while reports of 45 or 50 tons are not infrequent.

Root crops usually succeed best on deep, moist, friable loam soils. On clay land they grow too slowly, and the soil is also difficult to work. Ordinarily, land for roots is heavily manured in the fall and then plowed considerably deeper than for other crops. If the soil runs

together badly during the winter, it is replowed in the early spring. Instead of the above procedure, the manure is sometimes spread during the winter, the land plowed deep in the early spring, and a fine, firm seed bed formed immediately by disking, harrowing, rolling, planking, etc., as the conditions may require. Between the preparation of the seed bed in the early spring and planting the seed during April or early in May the land is cultivated sufficiently to keep the weeds subdued. Just before planting the seed a thorough cultivation is given, finishing with a planker or clod masher. This destroys the weeds, thoroughly pulverizes the soil, and leaves the surface smooth and in good condition for planting.

Mangel-wurzels and ruta-bagas are usually grown in rows from 22 to 30 inches apart. When planted in continuous rows, enough seed is used to insure a good stand. When sown with a hill-dropping planter, the hills are from 8 to 15 inches apart and 4 or 5 seeds are dropped in each hill. The rows of carrots are usually 18 inches apart and the hills 8 inches.

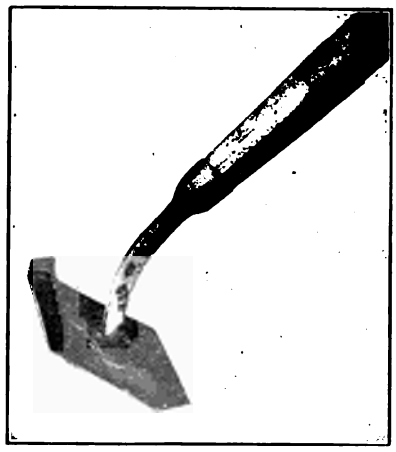

FIG. 3.—A "scuffle" hoe devised and used by W. J. Langdon, Sumner, Wash., in thinning and weeding root crops. A very effective implement.

As soon as the plants can be seen in the rows, the wheel hoe is started. With the guards of the hoe next to the row, the cultivation is done as close to the row as possible without covering or disturbing the plants too much. Considerable hand weeding and hoeing between the hills and along the rows is usually necessary. When the plants are 3 or 4 inches high, they are thinned, leaving the most vigorous plant in each hill. When sown in continuous rows, the thinning is largely done with a hoe, striking across the row. Subsequent cultivation should at least be sufficient to keep the weeds under control. As much of it as possible is usually done with a horse cultivator.

Instead of the common and wheel hoes for thinning and weeding, some prefer to use a "scuffle" hoe. (See figs. 3 and 4.) When in use, the blade of such hoes is in a horizontal position and is pushed and pulled just under the surface of the ground. The blade shown in figure 3 is diamond shaped, about 2 inches wide in the middle and one-half inch wide at each end, and about 8 inches long. About an

inch of the tip of one end is turned up at a right angle to form a guard for working close to small plants. The blade of the hoe should be sharp on both edges, so that it will cut each way when pushed and pulled. In order to make it take hold properly, it may be necessary to bend the edges of the blade down slightly. To give the handle the proper angle, the shank should be curved. It should flatten out into a narrow, thin plate about 2 inches long and fasten to the blade by means of two rivets. This hoe is not on the market, but may be made by any blacksmith. An old saw makes excellent blades. The shank should be made of Norway iron, so that it may be bent to give the handle the proper angle.

FIG. 4.—A "scuffle" hoe similar in principle to that shown in figure 3, devised by A. B. Leckenby, Seattle, Wash. The blade of either of these hoes may be made from an old saw blade.

Ruta-bagas are sometimes sown in drills in the early spring and transplanted like cabbage. The plants may be transplanted like kale, as the land is plowed. The roots of the plants are placed where the next furrow will cover them and the tops are left sticking out. For this method of transplanting, see the discussion of kale.

About the 1st of November the roots are topped, pulled, and placed in narrow bins in the barn. Upon the approach of cold weather they are covered with hay or straw. The tops are sometimes cut off with a sharp hoe and the roots then dug with a potato fork. More generally they are dug first, the worker pulling on the top of the root with one hand as he bears down upon the handle of the potato fork with the other. The roots of two or three rows are laid together with the tops one way. The tops are then cut off with a long-handled knife. Some twist the tops off, claiming that the roots do not bleed and wither so much as they do when the tops are cut off. Roots are grown mostly for winter use and are fed up to the 1st of April. They are generally sliced before being fed to dairy cattle. Some dairymen feed them whole, claiming that cows can handle large roots nicely and that, unless the slicing is carefully done, they do not choke so frequently when feeding on whole roots as they do on sliced roots.

The flat or fall turnip (*Brassica rapa*) is also grown in western Oregon and Washington. Since it matures quickly, grows mostly above ground, and has a flesh less firm than that of other roots it does not keep well and is adapted only to fall and early winter use. Its soft flesh and habit of growth above ground make it an admirable root to be harvested by stock turned into the field. It is usually sown broadcast on clean land about the 1st of July. It may be sown also in corn. If intended for winter use it should be gathered and put into bins before becoming water-soaked from fall rains.

SOILING (GREEN FEEDING) CROPS.

The mild winter climate and abundant rainfall of western Oregon and Washington make it almost an ideal region for the production of soiling crops. By the judicious selection and planting of crops green succulent food may be provided for the dairy cow during practically the entire year. That a much greater amount of feed can be obtained from the same area of land by this system as compared with pasturing is a fact well recognized by progressive dairymen. Much of the tillable land of this region is now very valuable. As values advance beyond the limit where farm land may profitably be used for pasture and it becomes necessary for the small farmer to keep the maximum number of stock upon his few acres of tillable land, the growing of soiling crops becomes of vital importance.

Below is given a list of the crops that are used for this purpose. The dates of planting and the approximate dates upon which these crops may be used are also given. It must be understood, however, that the variation in seasons prevents one from saying definitely when a crop will be ready to use. For further information regarding these crops the reader is referred to the discussion of each in the preceding pages of this bulletin.

Dates for planting and using soiling crops in western Oregon and western Washington.

Crops.	When planted.	When used.
Rye and vetch	September 1 to 15	April 1 to May 15.
Winter oats and vetch	September and October	May 15 to July 1.
Winter wheat and vetch	do	Do.
Red clover	[illegible]	Do.
Alfalfa	[illegible]	During June.
Oats and peas	February	Do.
Oats and vetch	do	June 15 to July 15.
Oats and peas	April	During July.
Rape	May 1	Do.
Oats and peas	May	During August.
Rape	June	Do.
Corn	May 10 to 20	During August, September, and October.
Turnips	July 1	Late fall and early winter.
Thousand-headed kale	March 15 and transplanted June 1.	October 15 to April 1.
Mangel-wurzels, carrots, and ruta-bagas	April	October 15 to April 1 (fed from bins, pits, or root houses).

SEEDING TIMBER BURNS AND BURNT SLASHINGS.

As previously stated, dense forests of evergreen timber cover a very large portion of western Oregon and western Washington. During the dry season of the year forest fires overrun large areas, killing practically all vegetation, and leaving a loose blanket of ashes on the surface of the ground. These burnt areas if left unmolested for a few years usually produce a dense growth of young trees and brush and are practically worthless for grazing purposes. In clearing land it also frequently happens that the timber and brush are slashed and burnt several years before the stumps are removed. By properly seeding these burnt areas they may be made to produce excellent pasture. Since the stumps are in the ground and there is therefore no chance to cover the seed, the seeding should always be done in the fall before the ashes have settled. The first rain that comes will then cover the seed sufficiently to insure good germination.

Since there is little chance to improve or renew the stand on account of the stumps and timber remaining on the land, only seed of those plants should be sown that last a long time, stand close cropping, and yet produce as much growth as possible. If the seed is sown in the unsettled ashes as indicated, little difficulty will be experienced in getting good stands of white clover, alsike clover, red clover, orchard grass, meadow fescue, timothy, and English rye-grass. A mixture of 1 pound of white clover, 3 pounds of alsike clover, 10 of orchard grass, and 10 pounds of meadow fescue per acre should give satisfactory results when sown in the unsettled ashes in the early fall. Timothy will also do well for this purpose. Red clover and English rye-grass are each short-lived and should form but a small portion of the mixture, if sown at all. Timber burns that have been seeded down in this way should be pastured pretty closely to keep down the young trees and brush. Goats will help to do this better than any other kind of animal. The success of seeding burnt areas in this way has been thoroughly demonstrated in many parts of the region. It is only a question of sowing the proper seed at the proper time.

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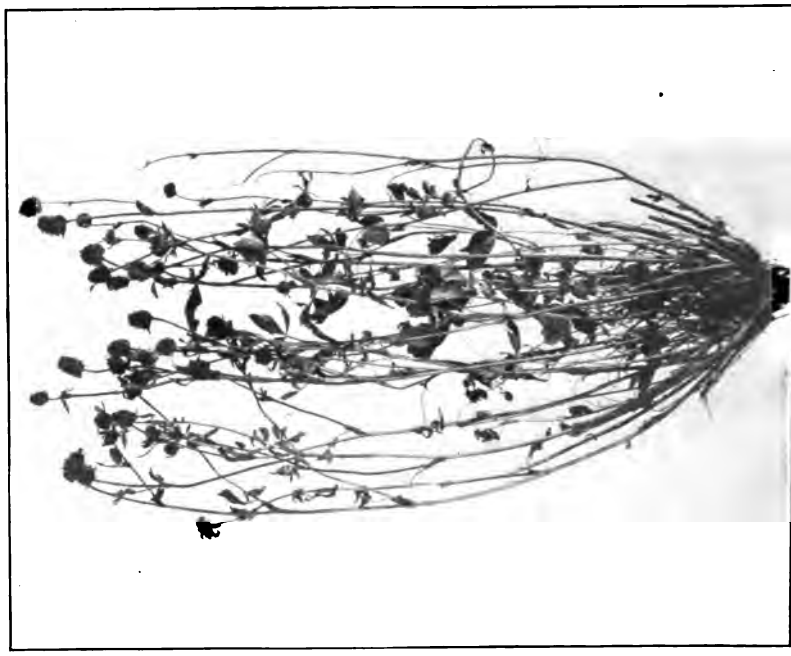

FIG. 2.—MATURE PLANT OF AMERICAN RED CLOVER.

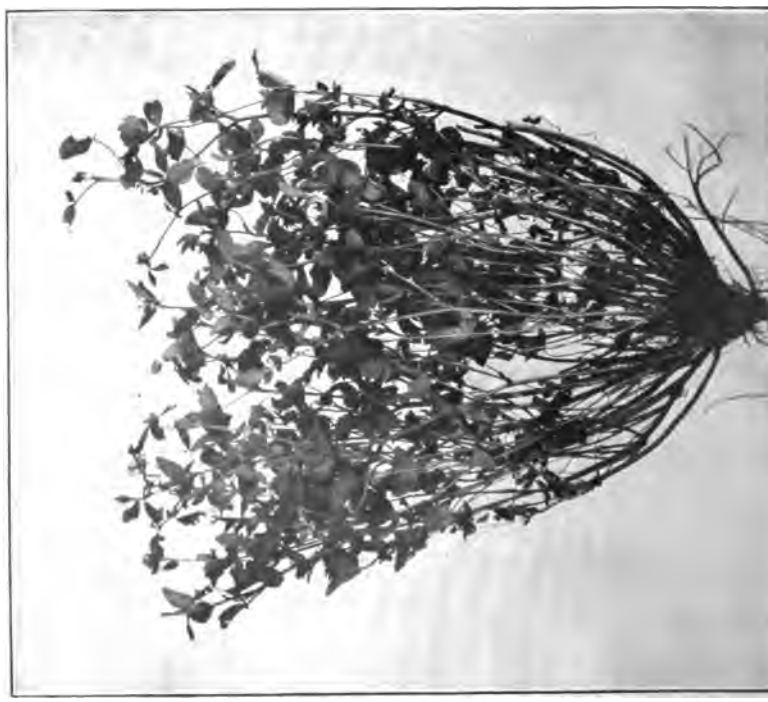

FIG. 1.—PLANT OF HAIRLESS OREL CLOVER, ALMOST MATURE.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 96.

B. T. GALLOWAY, *Chief of Bureau.*

PHILADELPHIA
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A NEW TYPE OF RED CLOVER.

BY

CHARLES J. BRAND,
ASSISTANT PHYSIOLOGIST, LABORATORY OF PLANT LIFE HISTORY.

ISSUED OCTOBER 3, 1906.

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., July 20, 1906.

SIR: I have the honor to transmit herewith a manuscript entitled "A New Type of Red Clover" and to recommend that it be published as Bulletin No. 95 of the series of this Bureau. This bulletin was prepared by Mr. Charles J. Brand, Assistant Physiologist in Plant Life History Investigations, and has been submitted by Mr. A. F. Woods, Assistant Chief of Bureau, with a view to publication.

Considering the great extent of the area suited to its cultivation, red clover is the most important forage plant and manurial force in modern agriculture. Its high value as a feed, its power of renewing and increasing the fertility of the soil by the fixation of free nitrogen, its fitness for nearly all rotations, and the fine physical condition in which it leaves the soil on account of its root development all contribute to make success in its cultivation a matter of vital importance to the profitableness of farming in a large part of the United States.

In the course of his studies on life history, seed production, and change of seed, Mr. Brand has encountered a European strain of red clover hitherto not recognized in this country, the seed of which was obtained from Orel in the "Black Earth" region of Russia, which promises to prove of exceptional value both on account of its yielding power and the fine quality of hay which it produces.

In the accompanying bulletin are described the performance and characteristics of the plant itself, the sections where and the conditions under which its culture may be expected to produce the best results. The new type is not recommended to take the place of our home-grown strains, but to supplement them. It is not believed that it will be so well adapted to all parts of the clover region as to the Northwest, but it is hoped that it may help to extend the boundaries of the present clover-growing area.

The work covered by this report has been carried on in cooperation with the Seed Laboratory and with the assistance of the Office of Seed and Plant Introduction and Distribution, through which all seed used in the experiments was purchased.

The accompanying illustrations are necessary to a full understanding of the text.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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A NEW TYPE OF RED CLOVER.

INTRODUCTION.

In the course of an investigation now in progress on the life history, seed production, and change of seed of medium red clover (*Trifolium pratense*), there has appeared a hairless Russian variety, new to the United States, of such unusual promise as to make it seem desirable to publish the observations thus far recorded concerning it.

At the present time clover culture is carried on in a large, though quite well-defined area of the United States, often called the clover region, shown on the accompanying map (fig. 1). Ohio, Indiana,

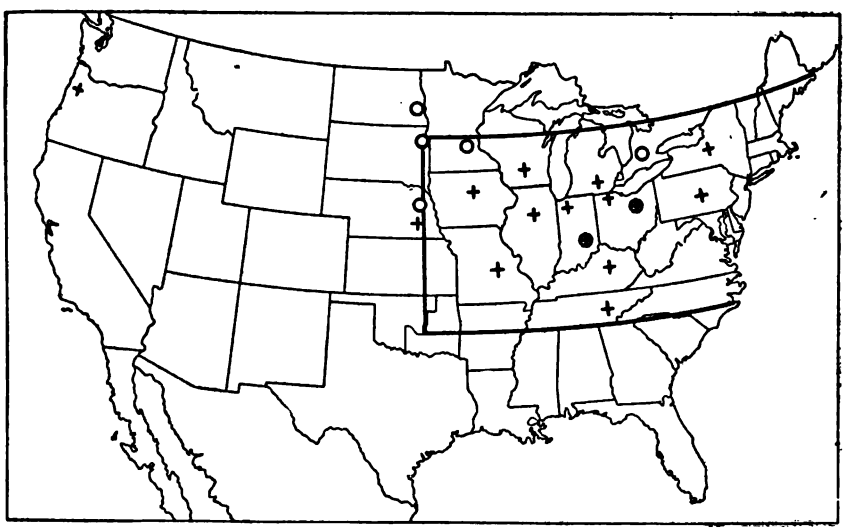

FIG. 1.—Map of the United States, showing locations of experiments (o), sources of seed (+), and general boundaries of the clover region.

and Illinois are the most important clover-producing States of this region, the boundaries of which may be defined about as follows: It is limited on the north by the forty-fifth parallel of latitude; on the east by the Atlantic Ocean; on the south by the thirty-fifth parallel, and on the west by the ninety-seventh meridian. These boundaries do not, of course, mark the absolute limits of clover culture, and it is almost unnecessary to say that there are large tracts within this so-called clover region where attempts to grow red clover are not

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attended with success. Furthermore, excellent growth is obtained in a few regions immediately adjoining this area, and there are also several sections wholly separated from it where clover is grown with notable success. Among the latter may be mentioned the Willamette Valley of Oregon, the Palouse country in eastern Washington, and also the Gallatin Valley of Montana, where red clover is being successfully and profitably grown under irrigation.

A lack of definite information has for a long time existed as to the exact life history requirements of red clover, the effect and importance of change of seed, and the relative seed and hay producing properties of the different varieties in use. It was to add to the sum of our knowledge on these and other points connected with clover culture that the present experiments were instituted.

THE IMPORTANCE OF CLOVER CULTURE.

The extraordinary importance of clover in renewing and maintaining the fertility of the soil has been amply demonstrated by the experience of thousands of American farmers and need not be dealt with to any length in this connection. It is sufficient to say that the thoroughly systematic and careful studies of recent years have proved conclusively that the beneficent effects of clover on the soil are due to definite symbiotic relationships which exist between the plant and certain bacteria inhabiting both the soil and the roots of the plants. Nitrogen, at once the most important and costly of plant and animal foods, is the element conserved in the soil or supplied from the air as the consequence of this relationship.

The need for broader knowledge concerning a plant of such vital importance to our present methods of agricultural practice is especially great just now when the status of clover culture in a large part of the clover region is so unsatisfactory. In those sections where the troubles attributed to "clover sickness" exist in an aggravated form, they threaten to make necessary new methods of agricultural practice in order to maintain farming on its present paying basis. Under the methods of farming now in vogue, red clover possesses the valuable manurial properties previously referred to in a higher degree of availability than any other leguminous crop plant at present capable of growth on a scale extensive enough to accomplish what is demanded in this direction in the large area suited to its cultivation.

These conditions make it seem advisable to place immediately at the disposal of the American farmer any facts likely to contribute to greater success in clover culture in its present well-defined area or to aid in its extension into sections where hitherto its culture has not been attempted or, if attempted, has been attended with only qualified success.

DOMESTIC VERSUS FOREIGN SEED.

The opinion has hitherto prevailed that the use of red clover seed from European sources would prove unsatisfactory and unprofitable in this country, both from a hay and seed producing standpoint. This conclusion no doubt applies correctly to the majority of European varieties of red clover, particularly those from Italy, France, and some parts of Germany, which appear to be altogether unsuited to the soil and climatic conditions of the clover-growing area of the United States.

The term "European clover seed" as used in the United States is a very loose inclusive one applied indiscriminately to all seed imported into this country from European ports. It includes not only seed grown in Europe, but also seed from South America, Canada, and the United States itself, the seed having been exported in years when the crop was large and prices consequently low only to be shipped back again to this country in years when the balance of supply and demand had shifted in the opposite direction. Inasmuch as red clover is grown to a large extent in almost all the countries of Europe and quite careful distinctions are made there between seed from a number of sources, the general designation of "European clover seed" hitherto used in this country appears altogether unwarranted and misleading. The same erroneous classification of American red clover seed is current in Europe, no distinction being made whether from New York, Tennessee, or Oregon. The following are some of the numerous regional varieties commercially well recognized in Europe: Steiermark, English, Bohemian, Russian, Danish, Swedish, and French. Some of these are again divided into early and late varieties; for example, Early Russian and Late Russian.

OBJECTIONS OF EUROPEAN GROWERS TO AMERICAN RED CLOVER.

One of the most frequent complaints made by European growers against American clover seed is on account of the dustiness of the hay produced from this seed. This dustiness is due almost wholly to the hairiness of the plant. That there is a great difference in this respect between the hairy domestic and smooth foreign types is strikingly shown in Plate II, figs. 1 and 2. The hairy form of plant shown was produced from American commercial seed, while the smooth one is a promising Russian clover from the government of Orel, designated as No. 16. This difference in hairiness is accompanied by other distinctions, the most important of which from an economic standpoint is the much greater succulence of the smooth plants and the consequently finer quality of the hay, the loss due to coarse, woody, uneatable stems being reduced to almost nothing.

HAIRY CLOVER A CAUSE OF BLOATING.

Cattle are less liable to tympanites, bloating, or hoven, if fed on the hairless Orel clover, as there is considerable evidence to prove that the hairs of the hairy varieties of clover become aggregated into balls in the rumen, and these may reach and block the pylorus or even the entrance to the stomach, becoming wedged between the lips of the esophageal groove. Either would tend to bring on bloating, which is always directly due to the fermentation of food material and the resulting formation and accumulation of gas.

That cattle prefer the smooth form to the American strains is undoubted. Mr. John P. Young, in cooperation with whom the experiments in Nebraska were conducted, states in a recent report that "the cattle fairly lick after every spear in one end of the rick for that Russian strain (No. 16), while the other end remains full of apparently just as good hay, put up at the same time and in the same way." (See Pl. I, figs. 1 and 2.)

SOME GENERAL OBJECTIONS TO THE GROWING OF CLOVER.

Two great objections have long been made against red clover culture in the area where it can be grown. One is that the hay crop matures at a time when the farmer's best interests demand that he be either cultivating his corn or harvesting his small grains. The other is involved in the fact that perhaps the most satisfactory, or at least the most popular method of seeding clover for hay or pasture is in mixtures containing either one or several of a number of grasses, including timothy, bluegrass, rye-grass, orchard grass, redtop, brome-grass, and others. Of these the most important by far is the clover-timothy mixture, and against this it has ever been argued that the clover matures so much in advance of the timothy that the feeding value of either the one or the other is sacrificed on account of the time of harvesting. This serious objection can be overcome in either one of two ways—the discovery or breeding of an earlier strain of timothy or of a later variety of clover.

Another objection to clover growing which is not infrequently heard is that the crop matures at a time in June when seasons of rainy weather are of frequent occurrence, making difficult or impossible the proper harvesting and curing of the crop, while beginning with the latter part of June rainy weather is much less common, conducing to the successful putting up of hay at this time. A cursory examination of the weather records of a number of States seems to indicate that there may be some ground for this objection.

CERTAIN OBJECTIONS OVERCOME BY NEW TYPE OF CLOVER.

The hairless Orel clover overcomes in an effectual way all the objections cited by maturing practically two weeks later than the domestic strains of medium red clover. This factor is of special

importance in sections where corn is the chief crop. At the time when a farmer is compelled to put up his clover hay grown from the ordinary strains of seed it is, as a rule, of the highest importance that he be concentrating all of his energies on the cultivation of his cornfields. The corn is rapidly approaching a stage when it becomes difficult or impracticable to cultivate longer. Inability to give the crop the necessary care at this time may mean hundreds of dollars of loss in a single year.

DISADVANTAGE OF LATENESS OF MATURING UNDER SOME CONDITIONS.

There is one drawback in the lateness of maturing of the Orel strain of clover, namely, that it militates against the production of a heavy second crop. However, in southern Indiana, in a typical part of the clover section, the Kief and Orel strains gave in the order mentioned the best yields of seed after recleaning. This is a point that will receive further investigation to determine as accurately as possible by a study of their limiting conditions the regions in which the new variety can be profitably grown.

HEAVY YIELD OF FIRST CROP AND ACCRUING ADVANTAGES.

The heavy yield of the first cutting of the hairless clover should prove indirectly advantageous in wheat-growing sections, especially in the winter-wheat belt, when it is desired to hasten the rotation back to wheat, as the increased product from this cutting would, where feed production was not a paramount necessity, in a measure justify the immediate or early plowing up of the field preparatory to reseeding to wheat. On account of the dense shade which this strain gives to the soil by virtue of its heavy growth, the field is left in unusually fine physical condition for plowing up after the removal of the first crop. A rotation practice of this kind might also prove valuable by postponing for several years the clover sickness from which all soils seem destined to suffer sooner or later. In the Dakotas and some other parts of the Northwest where fall plowing is necessary this method may be especially useful on account of the fact that as freezing up occurs so soon after the maturing of the second crop it is likely to be too late to prepare the land in the autumn for spring seeding.

OTHER POINTS OF EXCELLENCE OF HAIRLESS CLOVER.

In addition to the advantage of the smooth clover already mentioned—its exceptionally large yielding power for the first crop—the fine quality and dustlessness of its hay also command attention. In reference to its yielding qualities it will be seen later on that under comparable conditions in a number of different States it has outyielded from a few hundred pounds to almost two tons all of the

domestic strains that have been under test. This in itself is of great importance, but the actual gain in value is not adequately covered by this fact alone. On account of the succulence of the plants of this promising variety, the general quality and texture of the hay is so much finer that the percentage of waste, due to refusal of animals to eat hard, woody portions, is reduced to a minimum. Some observations on this point indicate that cattle waste from 5 to 10 per cent more of the coarse hay of other strains than of this hair-

FIG. 2.—Plant of *Trifolium pratense* var. *foliosum*, showing persisting basal leaves. (One-sixth natural size.)

less clover. The American strains vary considerably among themselves in this regard, but none of them compares favorably with either the Orel or Mogileff strains, particularly the former.

EFFECT OF PERSISTING BASAL LEAVES ON QUALITY OF HAY.

A point of considerable importance as regards the excellence of the hay produced by the hairless Orel clover No. 16 rests in the fact that it leafs much more profusely than the American forms. This may be seen by reference to the frontispiece (Pl. I, figs. 1 and 2).

Another feature in this connection, which is better illustrated than described, is shown in figure 2. Many leaves borne on the long stalks arising from short stems near the crown of the root persist in a growing condition until the plant is quite mature, and are cut with the hay. In the specimen from which the illustration was made the main stems were cut off, leaving only the basal leaves. Much of the leafiness observable in Plate I, figure 1, is due to the persistence of these leaves. Compared with that from American strains, a large percentage of the hay is made up of this tender leafy material, which improves its quality and increases its palatability. The American strains also produce these leaves, but not in such profusion, nor do they persist. (See Pl. I, fig. 2.) As a rule they become brown and dead, and if the weather be wet, decayed, and almost all fall off before the hay is made.

It is hoped that the smooth Orel clover will prove of permanent value especially in North Dakota and South Dakota, where clover culture is but little practiced and where on account of the waning productiveness of the soil, due to continuous cropping with wheat and other cereals, this crop is much needed for renewing and maintaining soil fertility.

LATENESS OF HAIRLESS CLOVER WITH REFERENCE TO INSECT RAVAGES.

A recent circular[a] prepared by the Bureau of Entomology calls attention to certain insects which destroy the clover seed crop and suggests as a method of preventing their ravages the clipping of the clover in May in order to cause blossoming to come on at a later date, when the danger from injury by these insects has passed. It is possible that the natural lateness of this new type of clover may accomplish this same result, thus doing away with the necessity for early clipping, which would probably make impossible the securing of more than one crop in any year.

A point of considerable interest and importance in reference to the general question of the harm done by insects was noted on the plants at Wapakoneta, Ohio. Grasshoppers were quite numerous and destructive in that section during the summer of 1905. The hairless Orel clover, known as No. 16, was not included in the experiment, but another smooth type from Kief, Russia, was tested at this place. It was found that the grasshoppers preferred the hairless clover to such an extent that they destroyed almost every plant of it, but did not molest the hairy American plants on the neighboring plats.

[a] "Some Insects Affecting the Production of Red Clover Seed." By F. M. Webster. Circular 69, Bureau of Entomology, U. S. Department of Agriculture, 1906.

Despite the numerous advantages possessed by this variety, it is not believed that it will supplant our domestic form, but rather, on account of its maturing between two cuttings of the latter, supplement it, especially when continuous green feeding is necessary or desirable.

EFFECT OF LATENESS OF MATURING WHEN SEED PRODUCTION IS DESIRED.

In many sections the lateness of this hairless strain of clover promises to be a drawback when it comes to seed production, as in years when it is desired to secure seed it may be possible to secure only either a light crop of hay from an early cutting, a small aftermath, or a considerable amount of pasturage.

SECTIONS PARTICULARLY SUITED TO THE CULTIVATION OF THE NEW TYPE.

In such a region as the Willamette Valley of Oregon, or in any other section where the best methods of management indicate that only one crop, either of hay or seed, and a light aftermath, or some good pasturage can be advantageously expected from clover fields, the extraordinarily heavy first crop, and the free seeding capacity of the late hairless clover make it especially desirable; and under such circumstances as these it can be recommended to take the place of our domestic form.

SEED OF NEW TYPE INDISTINGUISHABLE FROM ORDINARY FORM.

Another difficult, though not insurmountable, obstacle to the general use of this variety lies in the fact that the seed itself is indistinguishable from that in common use. However, as soon as there is a supply of seed and a demand for it, trustworthy dealers will no doubt furnish seed upon which dependence may be placed. The Department of Agriculture has at the present time only sufficient seed of this variety for experimental purposes and none for general distribution. Farmers purchasing seed from foreign sources purporting to be of the same kind are urged to take precautions against allowing any foreign weed pests that may be readily imported with the seed to gain a foothold in their fields. A number of the State experiment stations and the Seed Laboratory of this Department make purity and germination tests without charge; hence, a farmer before purchasing seed should avail of these facilities for insuring himself against introducing into his farm dangerous weeds or from buying seed of low germinating power.

In the following pages are given in detail the data concerning each of the strains experimented upon, special attention being given to the hairless Orel clover.

PLANS OF EXPERIMENTS, ORIGIN OF SEED, AND METHODS OF PROCEDURE.

For the present experiments about thirty regional varieties [a] of red clover seed were secured from as many domestic and foreign sources. Each station and individual cooperator has been furnished with a series including from 16 to 21 of these strains, and these are being grown side by side, in most cases on acre plats, under as nearly uniform conditions as possible. The varieties came from sources having a great diversity of climatic and soil conditions and methods of cultivation, and are now being grown under a range of conditions representing scarcely less diversity than those under which they originated. Twenty States are represented in the whole experiment, but of this number it is proposed to deal here only with those localities where the promising Russian variety before mentioned is being grown: Minnesota, North Dakota, South Dakota, Nebraska, Indiana, Ohio, and Ontario.

The circles on the sketch map of the United States (fig. 1) show the approximate location of each of the stations, while the crosses indicate the general region of each State from which the strains of known American origin were secured.

In the case of domestic varieties, every effort was made to secure seed that had been grown in the region of origin for a period of years and whose ancestry could as a consequence be followed to some extent. In most instances the American strains used are directly traceable to the identical field which produced them, and soil samples have been secured for examination and comparison with the soils into which they were transplanted. In the present bulletin only those varieties grown in comparison with clover No. 16, the promising Russian variety, will be discussed. All of the seed used in the work was secured by the Office of Seed and Plant Introduction and Distribution, the foreign seed through Dr. E. A. Bessey and that of home-grown varieties through the writer.

[a] The term "variety" is not used in its strict botanical significance, but is employed to designate seed from more or less widely separated sources.

The following table shows the region of origin of each strain grown in the different localities:[a]

TABLE I.—*Source of clover seed used in experiments and the localities in which it was tested.*

Source of seed.	Where tested.						
	Nebraska.	South Dakota.	Minnesota.	North Dakota.	Indiana.	Ohio.	Ontario, Canada.
1. Commercial seed (Western Bulked)	+	+	+	+	−	+	−
2. Western Ohio	+	+	+	+	+	+	−
3. Northern Indiana	+	+	+	+	+	−	−
4. Southern Indiana	+	+	+	+	−	+	−
5. Illinois	+	+	+	+	+	+	−
6. Missouri	+	+	+	+	−	+	+
7. Iowa	+	+	+	+	−	+	+
8. Commercial seed (not inoculated)	+	+	+	+	+	+	+
9. Commercial seed (inoculated)	+	+	+	+	+	+	+
10. Michigan	+	+	+	+	+	+	+
11. Nebraska	+	+	+	+	+	+	+
12. Eastern Ohio	+	+	+	+	+	−	+
13. Kentucky	+	+	+	+	+	+	+
14. Tennessee	+	+	+	+	+	+	+
15. Kief, Russia	+	+	+	+	+	+	+
16. Orel, Russia	+	+	+	+	+	+	+
17. Mogileff, Russia	+	+	+	+	−	+	+
18. Courland, Russia	+	+	+	+	−	+	−
19. Wisconsin	+	+	+	+	+	−	−
20. Oregon	+	+	+	+	+	−	−
21. Pennsylvania	+	−	+	−	+	−	−
22. New York	−	+	−	−	−	−	+

SOURCES OF RUSSIAN CLOVER SEED EXCEPT NO. 16.

Four Russian varieties were included in that part of the experiment under discussion, but, as may be seen by reference to Table I, not all of these were included in the series tested in each of the six States. Russian seed No. 15 was purchased in the open market under the trade name "Russian Rio." This seed was grown in the Province of Kief, in southwestern Russia, and, in common with all other strains used in this test, is of the crop of 1903. Seed from this same region, but of a previous crop, made a particularly good showing in Wisconsin in 1903, producing a plant that appeared to possess several excellent qualities not common to our own domestic strains. On this account a special effort was made to include a sample of this seed in these comparative experiments. Its productiveness and quality in 1903 were fully equaled in 1905, and but for the superior performance of No. 16, with which it has many points in common, it might well be recommended for use in the Northwest and elsewhere to take the place of our domestic strains. It has in all cases proved to be, like No. 17, intermediate in lateness of maturity, being later than No. 18

[a] The minus sign indicates that the strain opposite which it occurs was omitted from the series grown in the State specified.

and all the American strains, but earlier than No. 16, to which later experiments may show it to be superior under certain climatic and soil conditions.

Of the other three Russian varieties, Nos. 17 and 18 were secured from the following sources: No. 17 (S. P. I. No. 10533) was grown by M. Legsdin, near Shlobin (52° 50′ N., 30° E.) in the valley of the Dnieper, in the southern part of the Mogileff government, and was purchased from Mr. Heinrich Goegginger, of Riga. No. 18 (S. P. I. No. 10534) was obtained through Fr. Lassman, of Riga, and was produced near Neuhof (24° 35′ E., 56° 53′ N.), in the Baltic Province of Courland, on the estate of M. Sellin.

SOURCE FROM WHICH RUSSIAN SEED NO. 16 WAS OBTAINED.

The seed of the promising hairless clover No. 16 (S. P. I. No. 10532), to which it is desired to call special attention, was obtained by Dr. E. A. Bessey through H. Goegginger, of Riga, and was produced on the estate of a German grower near Yeletz, in the eastern part of the Orel government. The grower made a practice of saving his own seed, and hence this strain had been grown on the same estate for a number of years.

According to Mr. Goegginger, the government of Orel furnishes the best red clover seed obtainable in Russia. Its chief crops are winter rye and oats, and it is in rotation with these that the clover is grown. A small quantity of winter wheat is also grown.

THE SOIL AND CLIMATE OF OREL.

Yeletz is situated about longitude 38° E. and latitude 52° N., and lies well within the famous "Black Earth" or Tchernozom region of Russia. This region, comprising about 250,000,000 acres of the most fertile soil in the world, resembles strikingly in many features of both soil and climate our own Great Plains region. According to Sibirtzew [a] the Tchernozom extends from the Austrian and Roumanian frontier in a general east by northeast direction, forming a great band, varying in width from 250 to 650 miles, across the whole empire. The climate of this wonderfully fertile area is typically continental. The average mean annual rainfall of this region varies ordinarily between 16 and 22 inches and the temperature ranges from 30° F. or more below to more than 100° F. above zero.

According to Murchison, Verneuil, and Keyserling,[b] the black soil of the eastern part of the Orel government is especially rich in marl and limestone. In the light of our knowledge on the general beneficial effects of liming, it appears altogether probable that this factor

[a] Etude des Sols de la Russie. Compte Rendu Congrès Géologique International, St. Petersburg, 1899, pp. 73–125.

[b] The Geology of Russia in Europe and the Ural Mountains, London, 1846, Vol. II, pl. 6.

may contribute to a considerable extent to the success of clover growing in this area.

Orel occupies an elevated position in comparison with the governments which border it on the south; on this account its climate resembles more strikingly that of the states that bound it on the north. Its relatively high altitude, exposing it completely to the winds, is the cause of the more or less sudden changes in temperature to which this area is subject. These changes are induced by the warm winds which come from the south, southeast, and east, and by the cold winds from the north, northwest, and west. The mean annual temperature at Orel, the nearest point to Yeletz for which complete meteorological observations could be found, is 40.9° F. The seasonal means are as follows: Spring, 38.48° F.; summer, 66.11° F; autumn, 43.08° F.; winter, 15.08° F. The absolute maximum temperature thus far observed is 97.5° F., while the absolute minimum is −29.2° F. An average for a period of years shows 107 clear days, 127 with rain or snow, and 131 variable. The normal annual precipitation is 20.2 inches. The rivers of the Orel government are covered with ice on an average for 119 days during the year—from the first part of December until early in April. The climate will thus be seen to be a relatively temperate, continental one, resembling that of central Russia in general, but having somewhat more variable atmospheric conditions which often prove unfavorable to agriculture. Devastating storms are not infrequent in summer, while snowfalls accompanied or followed by high winds are common in winter.

From this brief characterization of the climatic conditions of the region from which Russian seed No. 16 was obtained, its likeness to that of our own northwestern prairie country can be easily seen, and added reasons for the promise of this strain of red clover in the Northwest are readily discernible. A beneficial change of seed has been accomplished between two regions having typically similar climatic conditions and soils that are singularly alike both in mechanical structure and chemical composition. The presence in both of a relatively large quantity of lime in a perfectly combined state is perhaps one of the most important similarities between these two widely separated soil areas.

The following table summarizes the more salient climatic features of Orel and the regions of America where clover No. 16 has already been grown and where, on the basis of the showing made in the growing season of 1905, the best results may be expected from its future cultivation:

TABLE 11.—*Temperature and rainfall of Orel, Russia, and certain localities in America.*

Location.	Temperature.						Precipitation.	
	Mean annual temperature.	Normal mean for January.	Normal mean for July.	Mean temperature of growing season.	Absolute minimum.	Absolute maximum.	Normal annual rainfall.	Normal rainfall of growing season
	°F.	°F.	°F.	°F.	°F.	°F.	Inches.	Inches.
Orel	40.4	13.4	66.8	61.59	−29.2	97.5	20.2	10.62
St. Paul, Minn.[a]	43.3	10.6	71.5	65.02	−41	104	26.99	17.39
Milbank, S. Dak.[b]	43	13.1	70.5	65.1	−34	107	20.73	13.73
Fargo, N. Dak.	38.7	5.4	68	62.5	−48	102	20.83	13.66
Tekamah, Nebr.[c]	49.2	22.7	75.3	68.7	−24	106	31.98	22.90
Guelph, Ontario	42.05	16.9	68	60	.....	.....	28.48	12.80

[a] St. Anthony Park, where these experiments were conducted, lies about midway between St. Paul and Minneapolis, Minn.

[b] No meteorological data are available for Bigstone, S. Dak.; hence the observations for Milbank, a point 11 miles distant, are here given.

[c] No meteorological data being available in the case of Oakland, Nebr., the records of Tekamah, a point 16 miles distant, are used.

PURITY AND GERMINATION OF SEED USED IN EXPERIMENTS.

In purchasing the different lots of seed used in the work, the greatest care was exercised to secure samples as free as possible from troublesome and injurious weeds, particular care being used with reference to dodder. All of the seed was of high average quality both as to purity and germination. The average purity of all samples as distributed for seeding was 98.13 per cent. As may be seen by an inspection of the following table, the seed showing the highest percentage of purity was that from Oregon, containing 99.68 per cent of pure seed, while the seed grown in New York contained the highest percentage of impurities, 7.46 per cent, or 92.54 per cent of pure seed. Every sample was screened from two to six times, one even twelve times, in order to remove as many of the impurities as possible.

The average germination of all samples was 87.07 per cent, the lowest percentage being 58.2 per cent for the seed from Courland, Russia; the highest, 99.12 per cent for the seed from eastern Ohio. Red clover seed germinating from 90 per cent to 95 per cent is generally considered as representing a satisfactory commercial product.

TABLE III.—*Purity and germination of red clover seed distributed in the spring of 1904.*

No.	Source of seed.	Purity.	Germination.
		Per cent.	*Per cent.*
1	Commercial seed (Western Bulked)	99.58	94.25
2	Western Ohio	98.42	75.62
3	Northern Indiana	97.7	88.2
4	Southern Indiana	98	94
5	Illinois	99	92.85
6	Missouri	96.8	88.27
7	Iowa	98.4	82.73
8	Commercial seed (not inoculated)	99.28	95.25
9	Commercial seed (inoculated)	99.28	95.1
10	Michigan	99.58	94.62
11	Nebraska	96.66	85.35
12	Eastern Ohio	99.56	99.12
13	Kentucky	99.48	73.85
14	Tennessee	97.98	92.5
15	Kief, Russia	98.4	88.75
16	Orel, Russia	95.5	87.85
17	Mogileff, Russia	98.34	91
18	Courland, Russia	97.62	58.2
19	Wisconsin	98.6	84.7
20	Oregon	99.68	91.54
21	Pennsylvania	97.58	91
22	New York	92.54	92.57

DETAILED DESCRIPTION OF EXPERIMENTS.

As previously stated, all of the seed used in these experiments was produced in the crop year 1903 and all of the experimental areas under discussion were sown in the spring of 1904. The observations made in each State will be discussed separately.

THE EXPERIMENT IN NEBRASKA.

LOCATION.

The work in Nebraska was carried on in cooperation with Mr. John P. Young, on his farm near Oakland, Burt County. This place is situated at about latitude 41° 50′ N. and longitude 96° 26′ W., in the Elkhorn Valley, near the present western limit of successful clover culture.

SOIL.

With the exception of a streak of limited extent, where the subsoil crops out, the soil of the clover field is a silted sandy loam of dark gray color and of such structure that with insufficient moisture it becomes aggregated into a hard, almost impenetrable mass. After rains it becomes very plastic and tenacious, very much resembling clay in this respect. On account of this character a large part of the soil of the Elkhorn Valley has become known under the name "clayland." This soil is further distinguished by a comparatively large percentage of well-distributed calcareous matter. This is a factor of great importance to successful clover culture, and no doubt helps to account for some of the heavy yields obtained in this soil.

DRAINAGE.

On account of a moderate slope in two directions the drainage of the experimental plats is excellent, none of them being so situated as to be in danger of suffering injury on account of standing water. The field contains 21 acres and was divided into as many equal parts, one being devoted to each of the regional varieties under test. In 1902 the field bore a crop of oats and in 1903 of corn.

PREPARATION OF LAND AND SEEDING.

In preparing the seed bed for the clover, the land was double disked with a pulverizing machine and well leveled with a common harrow.

Oats were used as a nurse crop, one half of all plats being sown to the Early Champion variety, the other half to the Kherson oats, a variety of Russian origin that has proved exceedingly valuable in Nebraska. The oat crop was harvested just after the middle of July, the Kherson variety yielding 35 and the Early Champion 25 bushels to the acre.

The clover was sown at the same time as the oats. Seeding began on April 15, but on account of unavoidable delays due to inclement weather was not completed until April 21. The seed was sown at the rate of 10 pounds to the acre, and by April 25 seedling plants had appeared on all the plats. After July 23, when the removal of the oat crop was completed, the clover had the whole use of the land. By the time for the cutting of the oats the clover had made a sufficient growth to be slightly clipped by the harvesting machine. Except for a light pasture with calves in November no further treatment was given the crop during the growing season of 1904

GENERAL WEATHER CONDITIONS DURING 1904.

The general condition of the weather throughout the season was favorable to securing a good "catch" of clover. There was plenty of rainfall during the season as a whole and no extended or injurious periods of drought occurred, although during September the dryness was sufficient to cause the soil to become very hard, as is characteristic of it when even moderately dry conditions prevail long enough.

COMPARISON OF STRAINS OF CLOVER ON ENTERING THE WINTER OF 1904.

According to notes taken by Mr. Young about the middle of November, 1904, there was a great degree of diversity in the general thriftiness of the various strains of clover when they entered the winter. In view of the data secured in 1905 the fact that the Iowa plat represented the normal or mean condition of all plats, the Nebraska strain standing next below it, is significant. In the data for the crop year 1905, given in Table VI, it will be noted that Nebraska seed

gave the lowest yield and Iowa seed next to the lowest. Taking Iowa as representing the average condition, the departure of each of the strains from the average is shown by the following table:

TABLE IV.—*Comparison of stand obtained from seed from various localities on plats at Oakland, Nebr., autumn of 1904.*

Above normal.			Normal.		Below normal.		
No.	Source of seed.	Rank.	No.	Source of seed.	No.	Source of seed.	Rank.
20	Oregon	1	7	Iowa.	11	Nebraska	1
5	Illinois	2			8	Commercial seed (not inoculated).	2
2	Western Ohio	3			9	Commercial seed (inoculated).	3
12	Eastern Ohio	4			15	Kief, Russia	4
19	Wisconsin	5			16	Orel, Russia	5
10	Michigan	6			17	Mogileff, Russia	6
21	Pennsylvania	7			18	Courland, Russia	7
3	Northern Indiana	8					
4	Southern Indiana	9					
14	Tennessee	10					
6	Missouri	11					
13	Kentucky	12					

This table shows that when winter set in in 1904 the plats sown to Kentucky, Missouri, and Tennessee seed were the most promising, in the order given. Two of those ranking below normal proved to be the best when the hay was harvested in 1905. These were the Orel clover No. 16 and the inoculated trade sample.

According to notes taken by Mr. Young, the plants produced by seed No. 16 were at this time "the weakest, most delicate, and farthest below normal" of any of the varieties included in the experiment. In view of the fact that in 1905 this clover outyielded the best of all the others by more than 1,000 pounds, this note is of unusual interest. Mr. Young further states that "it resembles somewhat the common white clover, only the plants are larger; but the leaves have that same appearance and are smaller than those on any of the other plats."

The winter of 1904–5 was quite severe, with temperatures reaching as low as 30° F. below zero. There were some days whose maximum only reached −20° F. However, as there was an abundance of snow the clover plants on all plats were adequately protected, and there was apparently no loss due to winterkilling. Without exception the plats were in excellent condition in the spring of 1905.

COMPARISON OF EARLY GROWTH OF CERTAIN STRAINS OF CLOVER.

By May 10 the different strains of clover had made average growths varying from 1 to 5 inches. The plat sown with Missouri seed showed the greatest average growth, while the Russian seed No. 18, from the Baltic Province of Courland, grew the least. The former had an average height of from 4 to 5 inches; the latter, from 1 to 2 inches. Despite this great discrepancy in early growth, the Russian strain was in bloom almost as soon as the Missouri strain and was ready for harvest in advance of it. The hay crop of the former was cut

on June 20; that of the latter, June 21. Unlike the Baltic strain, the Orel clover was the latest of all in coming into bloom, as well as the latest in coming to proper maturity for harvesting. It was harvested on July 11. It will be seen from this that a period of exactly three weeks elapsed between the date of cutting of the earliest and the latest strains. This fact is of direct importance under some conditions, as will be pointed out later.

WEATHER DURING GROWING SEASON OF 1905.

The weather during those months of the growing season preceding the cutting of the hay crop was in all respects favorable. The growth of the clover began in March, which month had a mean temperature of 44.8° F., more than 8.4 degrees below the normal. The mean temperature for April was 48.4° F., which is 3.2 degrees below the normal for that month. The precipitation aggregated more than 5 inches, 2 inches above normal. The temperature for May, 58.9° F., was 2.4 degrees cooler than the established normal for that month, while the precipitation, 4.76 inches, was practically normal. The June temperature of 70° F. was very near the normal, but the rainfall for that month, 2.75 inches, was more than 3 inches less than normal. None of the plats seemed to have suffered any injury despite the seeming dryness of the month. In July again the temperature was normal, while the rainfall was about 2 inches below normal.

EARLINESS OF VARIETIES AND ORDER IN WHICH THEY MATURED.

On account of their reaching maturity at practically the same time, the strains were harvested in the following groups. The varieties in each group are arranged as nearly as possible in the order of their earliness. The groups themselves are given in the same order, the earliest being first:

Group I.—Courland, Russia; Nebraska; Pennsylvania.
Group II.—Missouri; Iowa; Kentucky; Wisconsin.
Group III.—Eastern Ohio; Oregon.
Group IV.—Tennessee; Kief, Russia.
Group V.—Illinois; northern Indiana; Michigan; southern Indiana; northwestern Ohio.
Group VI.—The commercial samples, Nos. 1, 8, and 9; Mogileff, Russia; Orel, Russia.

Despite the fact that the earliest and latest maturing kinds are of Russian origin, it will be noted that the American strains present almost as great diversity in this regard. However, leaving out of consideration the commercial samples whose region of origin is unknown, the latest of the American strains of known origin is that from northern Ohio, which was grown west of Toledo near the northern boundary of the State. This strain came into bloom only nine

days later than the earliest of the American kinds, that from Nebraska. It will be seen from this that the range of maturing time of the American strains that are traceable to their region of origin as compared with the Russian varieties is very short indeed.

The table given below shows the date of full bloom of the earliest and latest American and Russian varieties:

TABLE V.—*Date of full bloom of earliest and latest American and Russian strains of clover.*

Earliest Russian.		Earliest American.		Latest American.		Latest Russian.	
Source.	Date.	Source.	Date.	Source.	Date.	Source.	Date.
Courland	June 20	Nebraska	June 20	Western Ohio.	June 29	Orel	July 11

Concerning the commercial samples used, it should be said that they were of most unusual purity, as well as of high average germination. The seed itself was very large and of a deep purple color, while the plants produced were coarse and hairy. This form seems to stand intermediate between the medium red, with which this experiment deals, and the well-known "mammoth" form of *Trifolium pratense*, which it resembles in some respects. Nothing is known as to the origin of this seed further than that it is supposed to have been produced in the Middle West. It came into full bloom on July 6, seven days later than the latest of American strains of known origin, and five days earlier than No. 16, the hairless form from Orel.

On account of the coarse, woody stems of the Western Bulked clover, there is a large percentage of waste in feeding its hay, the cattle refusing to clean it up as they do some of the other strains, notably No. 16. On account of the excessive hairiness of both stems and leaves the hay is very dusty, and hence not a pleasant and desirable feed.

The hay product of each of the different plats is shown by the following table:

TABLE VI.—*Comparison of yields of hay of regional varieties of red clover at Oakland, Nebr., in 1905.*[a]

No.	Source of seed.	Yield of hay.	No.	Source of seed.	Yield of hay.
		Pounds.			*Pounds.*
1	Commercial seed (Western Bulked)	5,700	12	Eastern Ohio	5,080
2	Western Ohio	4,980	13	Kentucky	5,540
3	Northern Indiana	4,780	14	Tennessee	4,670
4	Southern Indiana	5,020	15	Kief, Russia	5,840
5	Illinois	4,990	16	Orel, Russia	7,100
6	Missouri	5,010	17	Mogileff, Russia	5,750
7	Iowa	3,950	18	Courland, Russia	4,750
8	Commercial seed (not inoculated)	5,750	19	Wisconsin	4,950
9	Commercial seed (inoculated)	6,040	20	Oregon	4,930
10	Michigan	5,570	21	Pennsylvania	4,400
11	Nebraska	3,590			

[a] On account of a misunderstanding, the plats were not sown in serial order as given, but as follows: 11, 7, 1, 9, 8, 20, 10, 5, 3, 4, 2, 12, 19, 6, 13, 14, 15, 16, 17, 18, 21.

The first crop only was harvested for hay, the second being left to go to seed. The seed production of the various strains will be made the subject of further study.

The product of the plats sown with Western Bulked, Illinois, Iowa, Michigan, Nebraska, and Oregon seed was slightly reduced by a streak of subsoil which cropped out in these plats and on which the stand was not so perfect as on the other parts of the field. The resulting difference would amount to but a small percentage and would not modify materially the results as tabulated.

The Missouri plat was slightly injured in the spring by the work of ground moles, but seemed to have fully recovered from the injury before the cutting of the hay crop.

The only plat upon which any dodder appeared was that sown with the seed from Tennessee. It was promptly subdued and practically no harm resulted from it.

Although it would be unsafe to generalize from the results of one year's observation, it is interesting to note the fact that the seed produced in Nebraska and Iowa gave the lowest yields. This may be partially explained by the inferiority of the stand caused by the clay streak referred to above. However, it appears to the writer that this explanation is inadequate in view of the fact that the commercial samples which were grown on adjoining plats show no corresponding reductions in yield. As noted above, the Michigan, Illinois, and Oregon plats were crossed by the same streak of clayey subsoil.

YIELD OF THE OREL CLOVER COMPARED WITH OTHER STRAINS.

The total yield of all plats was 108,220 pounds, or about 54.1 tons. The highest yield was that of the hairless Orel clover, 7,100 pounds per acre; the lowest was from the Nebraska seed, 3,590 pounds, while the average for all plats was 5,153 pounds. It is interesting to note that three of the four Russian strains yielded considerably above the average for all plats.

The Orel clover No. 16 yielded 3,510 pounds of hay to the acre more than the Nebraska clover, giving a product almost double that of the latter. It produced more than 1,000 pounds more than its nearest competitor, one of the commercial samples, and almost a ton above the average for all plats.

THE EXPERIMENT IN SOUTH DAKOTA.

LOCATION.

The work for South Dakota is being carried on in cooperation with Flam Brothers on their farm near Bigstone, Grant County. Bigstone, which is situated 54° 10′ north latitude, 96° 26′ west longitude, is

in the northwestern part of the State. This station represents fairly well the conditions typical of eastern South Dakota and western Minnesota.

As in the case of Nebraska, the experimental plats were each an acre in extent, and the series of 22 varieties used was identical with the one grown in Nebraska, except that seed from New York was added.

SOIL AND DRAINAGE.

The field is a piece of bottom land bordering on a small creek. The soil, which is derived from the washing down of the surrounding prairie upland, is a black, sandy loam. The sand varies from medium to fine. The soil is productive, yielding excellent crops of wheat, oats, barley, corn, and millet. It is quite rich in calcareous matter. No definite rotation of crops including a legume has been practiced, and this is the first time the land has ever borne a crop of clover. On account of the excellent natural drainage due to the permeability of the soil and the elevation above the level of the creek it has not been necessary to resort to artificial drainage on the tract.

PREPARATION OF LAND, SEEDING, AND SUBSEQUENT TREATMENT.

No chemical fertilizers have ever been used on the field. In the spring of 1903 the tract was given a heavy dressing of barnyard manure, which was thoroughly worked in by the preparation given the land and by the cultivating of a corn crop planted that year. In the preceding year, 1902, the tract had grown barley and millet.

In preparation for the clover and the accompanying nurse crop of barley the land was deeply plowed in the fall of 1903, and in the spring of 1904 was harrowed until the seed bed was in suitable condition. The seeding of the barley, which was drilled in, took place during the last days of April. It was harvested in July, the field yielding an average of 50 bushels machine measure to the acre.

The clover was sown broadcast on May 5, and then lightly harrowed in. Before the tenth of the month, the first sprouts had appeared on each of the 22 plats.

After the removal of the nurse crop, no subsequent treatment was given the field during the growing season of 1904. Despite the fact that an unusual growth was made by the clover before wintering in, it was neither clipped nor pastured, on account of the uncertainty as to the effect this would have on the plats coming through the winter. The growth left on the field formed an excellent binder for holding the snow. This gave the plants a good protection from the cold during the winter, which in this latitude is very rigorous.

Observations made in October, about the time of the frost which terminated growth for the season, showed, as in the case of Nebraska,

considerable variation in the habit and development of the various plats, but on none of the plats was there any evidence of any failure to secure an excellent stand.

WEATHER CONDITIONS DURING 1904 AND 1905.

The state of the weather throughout the season was exceedingly favorable, there being plenty of moisture at all times. This is a factor of no small importance, especially at the critical period following the removal of the nurse crop. The loss sustained by the various strains on account of winterkilling during the winter of 1904–5 was comparatively small and probably did not reach more than 5 per cent in any case. The Missouri and Tennessee clovers were the worst sufferers in this respect among the American forms. The loss by winterkilling had no perceptible effect on the yield so far as could be observed; at least, the heaviest losers on this account were by no means those giving the lightest yields.

The weather for the months of April, May, June, and July, during which the growth of the hay crop took place, was decidedly abnormal for this section. The mean temperature for each of these months was below normal from 2.5 to 4.6 degrees. The precipitation, as is generally the case in comparatively cool seasons, was far above normal for each of these months, except April, when it fell below normal.

The weather records at Milbank, 11 miles distant, give the following data for these months in 1905:

TABLE VII.—*Temperature and rainfall at Milbank, S. Dak., during the growing season of 1905.*

Month.	Temperature.		Precipitation.	
	Mean for month.	Departure from normal.	Total for month.	Departure from normal.
	° *F.*	° *F.*	*Inches.*	*Inches.*
April	42.2	−2.7	1.25	−0.96
May	52.4	−4.6	7.35	+4.50
June	63.1	−2.5	8.60	+4.82
July	67.4	−3.1	5.27	+2.65

As in the case of Nebraska, there was great variation in the dates of first and full bloom; but inasmuch as careful notes of the actual dates were not kept, through inadvertence, it is impossible to report in detail on these points.

The first sample to come to the proper maturity for harvesting was that from Oregon, followed soon by the New York and Pennsylvania plats. A period of very rainy weather which followed the cutting and curing of these plats made it impossible for a time to proceed with the harvest, and on the night of July 3 came a veritable

cloudburst, more than 5 inches of rain falling. The neighboring creek overflowed its banks, inundating the whole bottom and submerging the clover plats with from 6 inches to several feet of water.

This misfortune threatened to make impossible the securing of further data concerning the varieties. However, the excellent drainage of the field saved it from serious injury, and at the end of a week it was possible to proceed with the harvest.

The following table shows the yield of cured hay produced by each of the strains used in the experiment at this place:

TABLE VIII.—*Comparative yield of hay of various strains of clover at Bigstone, S. Dak., in 1905.*

No.	Source of seed.	Yield of hay.	No.	Source of seed.	Yield of hay.
		Pounds.			*Pounds.*
1	Commercial seed (Western Bulked)	4,400	12	Eastern Ohio	4,640
2	Western Ohio	3,500	13	Kentucky	3,420
3	Northern Indiana	2,510	14	Tennessee	3,970
4	Southern Indiana	2,710	15	Kief, Russia	4,080
5	Illinois	3,990	16	Orel, Russia	5,610
6	Missouri	4,450	17	Mogileff, Russia	4,030
7	Iowa	4,130	18	Courland, Russia	3,280
8	Commercial seed (not inoculated)	3,998	19	Wisconsin	2,970
9	Commercial seed (inoculated)	4,312	20	Oregon	4,560
10	Michigan	4,400	21	Pennsylvania	1,800
11	Nebraska	4,500	22	New York	2,400

COMPARISON OF YIELDS.

The low yields of the samples of clover from western Ohio and northern Indiana are due to the injury they received from the flooding previously mentioned. A "run," or former creek bed, which extended diagonally across these two plats was transformed into a torrent and did considerable damage to both of them. With these exceptions the injury by water was equal on all plats. The comparatively low yield of the New York and Pennsylvania strains may be explained, in part at least, by the fact that the west side of the field, along which these were sown, had not been under cultivation as long as the remainder of the field and hence was not so well subdued.

The total yield of cured hay from the 22 acre plats was 87,982 pounds, an average of 3,998 pounds, or nearly 2 tons, to the acre. Leaving out of consideration the plats that suffered from apparent external injuries, the plat sown with Wisconsin seed gave the lowest yield of the domestic varieties, while that sown with seed from eastern Ohio gave the highest yield. The yield of the former was 2,970 pounds, something more than 1,000 pounds below the average for all plats, while that of the latter, 4,640 pounds, was about 650 pounds greater than the average.

As was the case in the experiments at Oakland, Nebr., the hairless Orel clover No. 16 gave not only the heaviest yield among the

Russian strains, but it outyielded every other variety used in the experiment. It produced 5,610 pounds of cured hay to the acre, which is more than three-fourths of a ton (1,612 pounds) better than the average for all plats, almost 1,000 pounds more than the best American strain (that from eastern Ohio), and more than a ton and a quarter (2,640 pounds) more than the lowest yield of the domestic strains growing under like conditions (that from Wisconsin).

In addition to its great yielding power, the other excellent qualities of this strain as observed in Nebraska were reproduced in South Dakota. The marked absence of hairiness on both stems and leaves, the erectness of habit, the profuseness of leafage, the comparative lack of waste on account of hard, woody stems, and a number of other desirable qualities were all strikingly apparent.

THE EXPERIMENT IN MINNESOTA.

LOCATION, SOIL, AND DRAINAGE.

The experiments in Minnesota were carried on on the University farm at St. Anthony Park, with the cooperation of the division of agriculture of the Experiment Station and School of Agriculture. The work here was instituted under the direction of Prof. W. M. Hays, and is now being carried forward with the assistance of Mr. A. D. Wilson, of the station staff. St. Anthony Park is located midway between Minneapolis and St. Paul at about latitude 44° 58′ N. and longitude 93° 90′ W.

In this experiment two series of plats were used on rather widely separated fields. The plats of one series were one-twentieth of an acre in extent, and the product of these was used in determining by weight the amount of green matter produced by each strain. The plats of the other series had an area of one-fourth of an acre each, and were devoted to securing data as to the production of cured hay. According to Hays and Boss[a] both the soil and immediate subsoil of the University farm are of medium texture, containing clay and sand mixed in such proportions as to facilitate a rather free absorption of the rainfall which penetrates to a considerable depth and is well conserved in seasons of moderate drought. At a depth of 5 or 6 feet, however, the mixture of clay and sand gives way to gravel and sand. This furnishes excellent underdrainage in years of abundant or superabundant rainfall, but is a serious drawback in years of drought, as it tends toward the dissipation of a part of the water supply of the crops through this deeper porous subsoil. The surface drainage, as well as the underdrainage, of both areas used in this experiment was excellent.

[a] Bulletin No. 62, Agricultural Experiment Station, University of Minnesota, March, 1899.

PREPARATION OF LAND, SEEDING, AND SUBSEQUENT TREATMENT.

Field F, which was used in making the green-matter determinations, was sown to Canada field peas in 1902, and in 1903 was used in the variety testing of cereals. The field was fall-plowed in 1903 and in the spring was disked and harrowed preparatory to seeding with clover. Spelt was used as a nurse crop. The clover seed and the spelt were mixed and sown with a drill.

Field W, from which the data as to field-cured hay was secured, bore a crop of fodder corn in 1902, and was manured and again sown to fodder corn in 1903. In preparation for the clover it was thoroughly disked and harrowed. The clover seed was drilled in to a depth of from 1½ to 2 inches, having been first mixed with the Minnesota No. 169 wheat, which was used as a nurse crop.

No treatment such as pasturing or clipping was given the field after the removal of the spelt and wheat.

WEATHER CONDITIONS DURING 1904 AND 1905.

The weather throughout the season of 1904, despite the fact that the temperature in most months was a little below normal, was quite favorable to securing a good "catch" of clover. The last killing frost in spring occurred on May 15, and the first in autumn on October 6. There was a plentiful supply of moisture at all times, the precipitation of every month during the growing season exceeding the normal.

According to notes taken shortly before the first killing frost of autumn, there was a fair stand on all plats at that time. The weakest strains were those from Tennessee, Orel, and Kief, while among the most vigorous were those from Ohio, Indiana, Wisconsin, and Iowa.

The winter of 1904–5 was rather severe on the whole, the means for both January and February being several degrees below normal. The minimum temperature recorded was 26° F. below zero.

No marked loss due to winterkilling was noted on any of the varieties under experiment, but on account of the coolness of April practically no growth was made until the last week of the month.

COMPARATIVE CONDITION OF DIFFERENT STRAINS OF CLOVER IN THE SPRING OF 1905.

On May 13 observations were made on the comparative condition of the stand on all the plats. According to these, of the seeds from domestic sources the strains from eastern Ohio, northern Indiana, and the commercial samples made the best showing at this time. The poorest of the domestic strains at this time were those from Tennessee, Missouri, Nebraska, Michigan, and Illinois. The best of the Russian strains were Nos. 15 and 17, from the Kief and Mogileff governments, respectively, while the poorest were Nos. 16 and 18, from Orel and Courland.

The best strain of known origin according to the observations of May 13 was that from eastern Ohio, while the poorest was that from Courland.

YIELDS OF GREEN MATTER.

The following table shows the yield and other data with reference to the series of plats used in determining the amount of green matter produced to the acre:

TABLE IX.—*Yields of clover on Field F used in making green-matter determinations, St. Anthony Park, Minn., 1905.*

No.	Source.	Date of first bloom.	Date of full bloom.	Date cut.	Average height when cut.	Green matter to acre.
					Inches.	*Pounds.*
1	Commercial seed (Western Bulked)	June 12	June 28	June 28	30	21,500
2	Western Ohio	June 13	June 27	do	31	20,900
3	Northern Indiana	June 11	June 26	do	30	22,000
4	Southern Indiana	June 9	do	do	30	20,400
5	Illinois	June 10	do	do	30	21,000
6	Missouri	June 12	do	do	28	19,400
7	Iowa	June 13	do	do	28	21,200
8	Commercial seed (not inoculated)	do	June 28	do	27	20,100
9	Commercial seed (inoculated)	June 12	do	do	28	19,900
10	Michigan	June 11	June 27	do	28	18,900
11	Nebraska	June 10	June 28	do	30	21,300
12	Eastern Ohio	June 11	June 27	do	30	21,700
13	Kentucky	June 12	June 25	do	20	21,400
14	Tennessee	June 11	June 27	do	30	18,000
15	Kief, Russia	June 10	June 25	do	29	21,000
16	Orel, Russia	June 15	(Practically no blossoms.)	do	30	24,100
17	Mogileff, Russia	June	June 30	do	31	24,400
18	Courland, Russia	June 15	June 27	do	28	20,000
19	Wisconsin	June 12	June 28	do	28	21,900
20	Oregon	June 13	June 27	do	27	20,000
21	Pennsylvania	June 12	do	do	26	20,600

COMPARISON OF CLOVER NO. 16 WITH OTHER STRAINS.

An inspection of Table IX shows that clovers Nos. 16 and 17, from Orel and Mogileff, respectively, were the heaviest producers of green matter, the yield of the latter being the greater. In this connection it should be noted that No. 17 was harvested after coming almost into full bloom, while No. 16, according to notes taken on the date of cutting, had practically no blossoms. From this it seems probable that the Orel clover was harvested fully two weeks before it had reached the same state of maturity that had been attained by the other strains. Despite this fact it was outranked in yield only by the strain from Mogileff, which lacked but two days of being in full bloom. There can be no doubt that the Orel strain would have given a yield of several thousand pounds more to the acre had it been allowed to reach the stage of maturity at which it is customary to cut clover for hay.

The Orel clover exhibited the same fineness of texture, absence of hairiness, erect habit of growth, succulence, etc., that were observed on the plats in Nebraska and South Dakota. These qualities

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are not by any means common to all of the Russian strains with which experiments have been made. Another strain not used in the States under discussion, obtained from Ufa, in the cold, almost snowless steppe region of eastern Russia, resembles No. 16 very strikingly. Nos. 15 and 17 resemble the foregoing in some of their qualities, but like No. 18, which in these respects is practically identical with the American strains, they are readily distinguishable in the field.

The lowest yield was given by the seed from Tennessee. The strains that produced less than 20,000 pounds of green matter are the Tennessee, Michigan, Missouri, and commercial sample No. 9. The largest yield produced by seed from domestic sources was 22,000 pounds in the case of No. 3 from northern Indiana.

YIELDS OF FIELD-CURED HAY.

Table X shows the yield to the acre and other data regarding Field W, which was devoted to determining the comparative production of field-cured hay.

TABLE X.—*Yields of clover on Field W, used in determining the production of field-cured hay, St. Anthony Park, Minn., 1905.*

No.	Source.	Date of first bloom.	Date of full bloom.	Date when cut.	Average height when cut.	Field-cured hay to acre.
					Inches.	*Pounds.*
1	Commercial seed (Western Bulked)	June 13	June 28	June 30	30	4,350
2	Western Ohio	do	June 27	June 29	31	4,246
3	Northern Indiana	June 15	June 28	do	30	4,468
4	Southern Indiana	June 14	June 27	do	30	4,800
5	Illinois	June 11	June 26	June 30	30	4,068
6	Missouri	do	June 25	do	28	4,400
7	Iowa	June 13	June 26	June 29	28	4,130
8	Commercial seed (not inoculated)	June 11	June 28	June 30	27	4,420
9	Commercial seed (inoculated)	June 12	June 29	do	28	4,394
10	Michigan	June 10	June 27	June 29	28	4,100
11	Nebraska	June 15	do	do	30	4,308
12	Eastern Ohio	June 12	June 26	do	30	4,800
13	Kentucky	June 11	June 27	do	30	4,120
14	Tennessee	do	June 25	do	30	3,040
15	Kief, Russia	June 13	June 28	June 30	29	4,000
16	Orel, Russia	June 16	(Few blossoms.)	do	30	5,320
17	Mogileff, Russia	June 15	June 30	do	31	5,000
18	Courland, Russia	June 13	June 27	do	28	3,780
19	Wisconsin	June 12	June 26	June 29	28	3,760
20	Oregon	June 13	do	June 30	27	4,460
21	Pennsylvania	June 10	do	June 29	26	4,460
	Total					91,035

ORDER IN WHICH THE VARIOUS STRAINS MATURED.

A variability similar in some respects to that observed in Nebraska may be noted with reference to the length of time required to mature the different strains. On the University farm they reached the

proper stage for harvesting in the groups given below, those maturing earliest being given first:

Group I.—Missouri; Tennessee.

Group II.—Illinois; Iowa; Wisconsin; Oregon; Pennsylvania; eastern Ohio.

Group III.—Kentucky; western Ohio; southern Indiana; Courland; Nebraska; Michigan.

Group IV.—Northern Indiana; commercial samples 1, 8, and 9; Kief.

Group V.—Mogileff.

Group VI.—Orel.

COMPARISON OF YIELDS OF FIELD-CURED HAY.

The lowest yield of the domestic varieties was 3,640 pounds, produced by the Tennessee seed, while the highest was 4,800 pounds, produced by the seed from eastern Ohio and southern Indiana. No. 18, from Courland, gave the lowest yield of the Russian sorts, 3,780 pounds, while No. 16, from Orel, gave the largest return of any variety in the test, 5,320 pounds. No. 16 was harvested on June 30, when it was still very immature, having but few blossoms. Inasmuch as increase in substance is progressing most rapidly in the period leading up to and just preceding full maturity, it is very probable that the Orel clover would have given a considerably higher yield had it been allowed to mature properly. Judging from the performance of this variety at other stations it should have been cut from ten to twelve days later than was the case. This fact should be borne in mind when noting that No. 16 yielded only 520 pounds more than its nearest competitor, 1,176 pounds more than the average for all plats, and 1,600 pounds more than the poorest strains.

THE EXPERIMENT IN NORTH DAKOTA.

LOCATION, SOIL, AND DRAINAGE.

The experiment in North Dakota was conducted on the Experiment Station farm, near Fargo, in cooperation with Prof. J. H. Shepperd, who has been assisted by Mr. O. O. Churchill.

On account of the fact that a larger area was not available, the test was made on half-acre plats. With one or two exceptions the same series of varieties was used as in Nebraska, South Dakota, and Minnesota.

The field used has a wonderfully uniform soil, consisting of jet black clay loam several feet in depth. It is rich in organic matter and in lime, both in the form of carbonate and sulphate. The subsoil is a silty clay of grayish-brown color, which extends to a depth of

about 6 feet. The surface soil seems to have a slight admixture of the heavy, black, waxy, clay soil locally called "gumbo." The general soil of the field is quite typical of the best soil in the Red River Valley.

Continuous cropping with wheat has seriously depleted most of the soils of this valley, and they no longer produce the abundant yields that characterized them from ten to twenty years ago. No systematic rotation of crops containing a legume is in general use, and to this may justly be attributed the gradual running down of yields of the cereals which have hitherto been cultivated almost exclusively. The growing of clover is an undeveloped industry in North Dakota. This is due in great part to the fact that wheat farming has hitherto been so profitable, and to the further fact that until recently a general impression has prevailed that clover growing could not be carried on with success. The work of the State Experiment Station during recent years has amply demonstrated that eastern North Dakota, at least, may be considered as peculiarly adapted to clover culture. The writer has never seen anywhere in the clover-growing regions of the United States a finer field of clover than that on which this experiment with regional varieties was conducted. (Pl. III, fig. 1.)

The drainage of the experimental tract is, in common with most of the soils of the Red River Valley, rather poor. This applies to both surface drainage and underdrainage, and is due to the practically "dead level" of the country, which gives the rivers draining the area a very slight fall, and also to the impermeability of the soil to water. In this connection a fact of some interest and possible importance was noted during the summer of 1905, when on account of the wetness of the season it was impossible to harvest a large percentage of the wheat crop of the valley. The clover field, on account of the magnitude of the transpiration of this crop, repeatedly became dry enough to cut after a few days of sunshine, while the neighboring fields of ripened wheat never dried out sufficiently to permit of their being harvested. In regions having heavy soils, where the most rigid conservation of moisture is not necessary, this fact may furnish an added reason for every farmer's sowing clover seed at the rate of from three to six pounds per acre with all of his small grains.

PREPARATION OF LAND, SEEDING, AND SUBSEQUENT TREATMENT.

In regard to the crops previously grown on the field, preparation of the seed bed, nurse crop used, and notes concerning the growth of the strains during the first year, the data below are given from Professor Shepperd's annual report for 1904.[a]

The land used for this trial produced a crop of corn in 1902, barley in 1903, and clover trial plats were seeded with wheat as a nurse crop in 1904. The field had been fall-plowed in 1903. It was disked on May 10 and harrowed twice with a peg-toothed harrow on May 11. The land was very wet in the spring and after the excess of water finally evaporated a period of very dry weather caused the soil to bake. The seed bed was far from being in an ideal condition on May 12, the date upon which the wheat was seeded. The wheat was sown at the rate of 5 pecks per acre with Fife seed. Four days later the clover seed was sown by hand at a rate slightly less than 10 pounds per acre. The clover seed was covered by harrowing with a peg-toothed harrow.

Notes recorded June 15 state that the wheat was showing a good stand and that the clover plants had appeared above the surface. On the above date it was observed that the clover was showing especially well upon the higher places in the almost level field.

On the dates July 25 and 26, the wheat, which was just forming kernels, was cut for hay and removed from the field. The sickle bar was set as high as the machine would allow and left the stubble about 5 inches high. The best of the clover was so high upon that date that it was clipped off by the sickle.

On August 2 Missouri (No. 6), Eastern Ohio (No. 12), Russian (No. 15), and Wisconsin (No. 19) made a much better showing than the plats from other sources of seed. Observations recorded on September 10 show especially favorable to Missouri (No. 6) and Wisconsin (No. 19), while Illinois (No. 5) and Russian (No. 15) were also reported as showing well.

WEATHER CONDITIONS DURING 1904 AND 1905.

On September 10, 1904, immediately after which date a killing frost occurred, there seemed to be a sufficient growth of clover and of wheat stubble to form a moderate winter protection for the clover plats.

With the exception of August, which had a total precipitation of only 0.69 inch, there was an abundance of moisture throughout the growing season. The mean temperature during June, July, and August was from 2 to 5 degrees below normal.

The winter of 1904–5 was quite severe, but in spite of the long-continued cold and low temperatures no loss due to winterkilling was observed on any of the plats.

According to notes taken on May 1 the strains from Mogileff, Courland, Michigan, Kentucky, and Tennessee, in the order given, showed the poorest stands. The best stand of all was on the Illinois plat, which was closely seconded by those sown to seed from eastern Ohio and Nebraska.

[a] Fifteenth Annual Report, North Dakota Agricultural Experiment Station, pp. 96–97.

The following table shows the comparative yield of each variety under experiment, also date of first bloom, full bloom, and cutting, and average height of plants when cut:

TABLE XI.—*Yield, time of first and full bloom, height, and date of cutting of clover at Fargo, N. Dak., 1905.*

No.	Source.	Date of first bloom.	Date of full bloom.	Date when cut.	Average height when cut.	Yield.
					Inches.	*Pounds.*
1	Commercial seed (Western Bulked)	June 20	July 8	July 8	30	5,220
2	Western Ohio	do	July 7	do	27	4,950
3	Northern Indiana	do	do	do	29	4,464
4	Southern Indiana	do	do	do	29	4,860
5	Illinois	do	do	do	28	4,830
6	Missouri	do	do	do	29	5,510
7	Iowa	do	do	do	29	3,940
8	Commercial seed (not inoculated)	do	do	do	30	4,680
9	Commercial seed (inoculated)	do	do	do	30	4,140
10	Michigan	do	do	do	32	3,750
11	Nebraska	do	do	do	28	5,080
12	Eastern Ohio	do	do	do	32	5,370
13	Kentucky	do	do	July 10	27	4,610
14	Tennessee	do	do	do	30	5,090
15	Kief, Russia	do	do	do	28	4,300
16	Orel, Russia	(No blossoms when cut.)		do	34	4,062
17	Mogileff, Russia	(Few blossoms when cut.)		do	28	4,350
18	Courland, Russia	June 20	July 7	do	30	4,470
19	Wisconsin	do	do	do	28	4,380
20	Oregon	do	do	do	28	4,300

COMPARISON OF YIELDS.

The heaviest yields of American strains of clover of known origin were secured from the Missouri and eastern Ohio samples, followed rather closely by those from Tennessee and Nebraska. The lightest yields of the American strains were obtained from seed from Michigan, Wisconsin, and Oregon.

The Russian strains were among those giving the lowest yields, the Orel clover yielding next to Michigan seed, the lightest crop. Clover No. 18, the earliest in maturing, produced the largest crop of the Russian sorts.

The low yield of clover No. 16 is adequately accounted for by the fact that in order to insure the securing of seed of this variety the plat was cut two weeks before it had properly matured. Plate III, figure 1, shows the Orel clover, immature and without blossoms, in the foreground, the more mature Russian form from Kief in the near background, and the fully matured Tennessee plat in the farther background.

Here, again, the hairless form exhibited all of the desirable forage qualities noted at the other stations, and but for being harvested so exceedingly early would no doubt have shown the same yielding qualities as elsewhere.

The following table summarizes the yields of each of the varieties grown in the experiments described above:

TABLE XII.—*Comparison of yields of field-cured clover hay at all northwestern stations, 1905.*

No.	Source.	Nebraska.	South Dakota.	Minnesota.	North Dakota.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
1	Commercial seed (Western Bulked)	5,700	4,400	4,320	5,220
2	Western Ohio	4,980	3,500	4,248	4,950
3	Northern Indiana	4,780	2,510	4,468	4,484
4	Southern Indiana	5,020	2,710	4,800	4,860
5	Illinois	4,990	3,990	4,068	4,830
6	Missouri	5,010	4,450	4,400	5,510
7	Iowa	3,750	4,130	4,120	3,960
8	Commercial seed (not inoculated)	5,950	3,998	4,420	4,680
9	Commercial seed (inoculated)	6,040	4,312	4,394	4,140
10	Michigan	5,570	4,400	4,109	3,750
11	Nebraska	3,590	4,500	4,308	5,080
12	Eastern Ohio	5,080	4,640	4,800	5,370
13	Kentucky	5,540	3,420	4,120	4,610
14	Tennessee	4,670	3,970	3,640	5,090
15	Kief, Russia	5,840	4,080	4,020	4,200
16	Orel, Russia	7,100	5,610	5,320	4,062
17	Mogileff, Russia	5,750	4,030	5,000	4,350
18	Courland, Russia	4,570	3,280	3,780	4,470
19	Wisconsin	4,950	2,970	3,760	4,380
20	Oregon	4,930	4,560	4,460	4,300
21	Pennsylvania	4,460	1,800	4,480	.....
22	New York	.....	2,400	.....	.....

OTHER EXPERIMENTS IN WHICH CLOVER NO. 16 WAS INCLUDED.

In addition to the Northwestern States already mentioned, to whose conditions the hairless clover seems best adapted and where its performance has been described in some detail, this form was also grown in the following sections:

(1) In Ohio, in cooperation with the Agricultural Experiment Station, on the farm of Mr. E. D. McIntyre, near Wooster. The work here was under the direction of Prof. C. E. Thorne, director of the station.

(2) In Canada, on the farm of the Ontario Agricultural College and Experiment Station. The work here was done under the immediate direction of Prof. C. A. Zavitz, experimentalist.

(3) In Indiana, in cooperation with Mr. Theo. H. Reed, on the farm of Mr. L. B. Harris, near Rushville, Rush County. This county is in the heart of the heaviest clover-seed-producing section in the United States and, according to the census of 1900, produced more clover seed than any county in the country.

At Wooster the Orel clover gave one of the highest yields, while at Rushville it produced one of the poorest crops of all the varieties tested, which was probably due to the fact that it was harvested before maturing. Although its forage qualities and botanical characters were identical with those exhibited at other stations, this variety does not seem to be particularly adapted to the conditions existing in Ohio and Indiana.

In Ontario, however, the Orel clover and a somewhat similar form from Ufa gave the heaviest yields. The data for this station are so complete that they are given in full in the following table. A number of varieties were here included that were not used in experiments in the States previously described. The data for these are also included. The experiment was made on small plats, from which the acre yields have been computed. (See Pl. III, fig. 2.)

TABLE XIII.—*Yield and other data for clover grown at Guelph, Ontario, in 1905.*

No.	Source of seed.	Date of first bloom.	Date of full bloom.	Date when cut.	Average height when cut.	Yield of green matter to acre.	Yield of cured hay to acre.
					Inches.	*Pounds.*	*Pounds.*
1	Commercial seed (Western Bulked).	June 15...	July 2.....	July 13....	30	18,640	3,63[illegible]
2	Western Ohio.....	June 16...	June 28...	July 3.....	30	18,120	2,7[illegible]
3	Northern Indiana.....	June 15...	June 27...	June 30...	26	19,080	2,[illegible]
4	Southern Indiana.....	June 13...	.....do....	June 29...	26	18,400	2,4[illegible]
5	Illinois.....	.....do....	.....do....	June 30...	27	18,240	2,720
6	Missouri.....	.....do....	.....do....	July 3.....	27	16,280	2,4[illegible]
7	Iowa.....	June 15...	.....do....	.....do....	27	16,880	2,[illegible]
8	Commercial seed (not inoculated).	.....do....	June 30...	July 7.....	29½	18,080	3,5[illegible]
9	Commercial seed (inoculated).	.....do....	June 29...	.....do....	28½	18,360	3,530
10	Michigan.....	June 13...	June 26...	June 29...	27½	18,200	2,2[illegible]
11	Nebraska.....	.....do....	June 27...	June 30...	27½	18,920	2,720
12	Eastern Ohio.....	.....do....	.....do....	.....do....	26	17,160	2,3[illegible]
13	Kentucky.....	June 14...	June 28...	July 5.....	27½	17,120	2,8[illegible]
14	Tennessee.....	.....do....	June 29...	.....do....	29½	17,680	2,[illegible]
15	Kief, Russia.....	June 17...	June 30...	July 11....	27½	15,560	2,[illegible]
16	Orel, Russia.....	June 18...	July 14...	July 16....	26½	20,800	4,[illegible]
17	Mogileff, Russia.....	June 17...	July 2.....	July 13....	30	19,320	4,080
18	Courland, Russia.....	June 14...	June 29...	July 5.....	29	23,280	2,[illegible]
19	Wisconsin.....	June 13...	June 27...	July 6.....	28½	17,240	2,980
20	Oregon.....	.....do....	June 28...	.....do....	29½	16,880	2,[illegible]
21	Pennsylvania.....	.....do....	June 26...	July 2.....	27½	19,000	2,9[illegible]
22	New York.....	June 16...	June 29...	July 7.....	29½	19,280	3,[illegible]
24	Vitebsk, Russia.....	June 14...	.....do....	July 6.....	30½	19,360	3,2[illegible]
25	Perm, Russia.....	June 16...	.....do....	July 12....	31	18,840	3,[illegible]
28	Ufa, Russia.....	June 18...	July 8.....	July 17....	26	21,040	4,5[illegible]
29	Kief, Russia.....	June 16...	July 2.....	July 11....	29½	20,240	3,440

Here, again, as was the case in the Northwest, the hairless Orel clover was the latest variety in maturing, and in yield it was surpassed only by the strain from Ufa. The Michigan seed gave the lowest yield of all, 2,240 pounds, while the New York seed gave the highest of the American strains of known origin, 3,640 pounds.

Clover No. 16 yielded 2,120 pounds more than the poorest and 720 pounds more than the best domestic strain, and it produced 1,600 pounds more than the average of all plats.

The same characters and qualities previously noted in this variety were found constant in this experiment.

The record of mean temperatures and precipitation at Guelph for the months of the growing season of 1905 up to and including the time of harvesting the hay crop, in comparison with the normals for the same months at Orel, follows:

TABLE XIV.—*Temperature and rainfall for certain months during 1905 at Guelph, Ontario, compared with the normals for the same months at Orel, Russia.*

Month.	Temperature.		Precipitation.	
	Guelph.	Orel.[a]	Guelph.	Orel.[b]
	Mean.	Normal.	Total.	Normal.
	°F.	°F.	Inches.	Inches.
April	41.15	38.08	1.75	1.57
May	52.84	56.10	3.89	1.87
June	62.58	63.55	3.54	1.97
July	67.67	67.76	4.66	2.80

[a] Wild, Die Temperaturverhältnisse des Russischen Reiches, St. Petersburg, 1881.
[b] Wild, Die Regenverhältnisse des Russischen Reiches, St. Petersburg, 1887.

DESCRIPTION OF NEW TYPE AND NAME PROPOSED.

Although American red clovers from widely separated sources vary greatly among themselves, these variations do not appear to be constant and are not of sufficient importance in any case to justify the giving of varietal rank in the botanical sense to any of the regional strains of domestic origin used in these experiments. On the other hand, the distinctions between the hairless Orel clover and the American clovers are so numerous and well defined in the plant itself, though not apparent in the seed, that it seems advisable, on account of the probable economic importance of the former, to give it a distinct varietal name. Almost complete lack of hairiness is perhaps the most striking distinguishing mark of this form in the field, but the variability in amount of hairiness, differing as it does even in American strains from more or less widely separated sources, makes this an undesirable quality on which to base a name. On account of the value both from an economic standpoint and as a botanical character of the general leafiness of the plant and the persistence and number of basal leaves produced, the writer proposes for this variety the designation *Trifolium pratense* var. *foliosum*, based on these characters. A type specimen has been deposited in the National Herbarium.

In addition to lack of hairiness and the unusual leafing qualities referred to above, the plants of this variety have a more upright habit of growth and branch more freely than the American form. Besides the foregoing, there are other differences of a more purely botanical character. The white spots on the leaflets which are so prominent in the ordinary form are frequently absent from plants of this variety and often when present can scarcely be seen. The largest mature leaves of the smooth clover are about the same size as the smallest of the American strains. The flower heads are also smaller, less compact, and rather more elongate than those of the latter. The bracts subtending the inflorescences are smaller in this form; also more circular in outline, less prominently nerved, of finer

texture, and glabrous throughout except at the apex, which is some times tipped with a few slender hairs. In the American form th under side and margin of these bracts are covered with many fin hairs.

The stipules also show some constant dissimilarities. On plant of equal age the stipules of the American strains are larger, hairy o the back, margins, and tip, and in the cured hay are harsh and woody in the Orel clover they are smaller, of finer texture, much less prom inently veined, and hairless except at the tip, where there is usually a tuft of hairs. According to a comparison of a large number o measurements of the stipules and petioles of the basal leaves of both forms, although the stipules of No. 16 are shorter, the petioles ar longer. In the former the stipules constitute about 8 per cent o the total length; in the latter, about 15 per cent. The average length of the stipules in both No. 16 and the American forms was found t be 22 mm. and 24 mm., respectively, and of the petioles 270 mm and 160 mm., respectively. The same proportion was not found t hold true in regard to the leaves of flower-bearing stems. In these both the stipules and petioles, comparing similar parts of plants o about equal development, are shorter in the hairless form. The average lengths of stipules and petioles in the latter are 20 mm. and 104 mm., while in the domestic form they are 22 mm. and 114 mm., respectively. (See Pl. II, fig. 1.)

The calyx of the smooth clover is sparingly covered with short, appressed hairs, while in the hairy American form it is densely covered with more erect hairs, which are in general from 1½ to 2½ times longer. The calyx in both forms is five-toothed, one tooth being considerably longer than the other four. In the American form the long tooth appears to be always more than twice as long as the four short ones, which are of about equal length, while in the variety *foliosum* the long tooth seems never to be as much as twice as long as the others.

The few hairs that occur on the Orel clover, no matter upon what portion of the plant they are found, are comparatively very short and always appressed to the part bearing them, while in the domestic clover they are numerous, in young plants matted (see Pl. II, fig. 2), and extend at right angles from the organ on which they are borne.

LATER OBSERVATIONS.

Notes taken during May and June of 1906 on the plats in Nebraska and North Dakota, now in their third year, tend to confirm the observations recorded for all stations during the growing season of 1905. In only one case was the seed production of clover No. 16 satisfactory under the method of taking two full crops. This was in southern Indiana, where its yield was fully up to the average for other varieties.

, Carlton, Oreg., on Mr. F. J. Canfield's farm, another late Russian ain, resembling No. 16 in many respects, gave a very satisfactory ld of seed. In this case only one crop, the seed crop, was harsted, the field having previously been pastured quite closely with gs and sheep until early summer. Although cut at the same time the earlier strains, the late Russian form indicated such promising elding qualities as to insure a large crop of seed with proper handling. e need for having all strains ready to hull at the same time made cessary the too early cutting of this strain, which was obtained from a and has been previously referred to in connection with the experient in Ontario.

From the observations made on the seed production of clover No. , it is evident that the chief obstacle to the successful introduction the new variety into commercial culture rests on the fact that seed ue to type will be difficult to secure, and when it has been secured it ll require some time before a sufficient quantity will have been opagated to sow any considerable area. For this reason it is sugsted that growers securing seed of this variety from any source hatever should devote the greater part of their field to seed producn. On account of its lateness it may not be possible, except in uthern parts of the clover region, where the seasons are long, to cure both a hay and a seed crop in any one year. Therefore growers the North and Northwest are advised not to attempt to secure two ll crops, but rather to mow a light crop of hay late in May—say, etween May 20 and June 1—and then allow the field to go to seed. In ctions where the practice of pasturing is permissible it may prove ore profitable to pasture the fields until about May 25 instead of king off an early cutting. The date of this cutting or of the pasturg will of course vary in different sections.

On account of the persistence of the leaves and the general characr of plant, the straw that remains after hulling clover No. 16 should rnish considerably more feed than that of the hairy type of clover.

The fact that the seedlings of the new clover are almost absolutely ee from hairiness may prove a help in determining the genuineness any sample. Where seed is purchased long enough in advance of eding to make it possible, the germination test could be prolonged in ots for thirty days with a view to examining the seedlings. By this me the ordinary clovers are very hairy, while No. 16 remains almost erfectly smooth.

The Department of Agriculture is making an effort to secure a new nportation from the same source as the original seed used in these xperiments. This seed when obtained will be planted for the most art in large fields in order to secure a supply for use in distribution nd for experimental work.

A very interesting fact in connection with the 3-year-old plats of the Orel clover, indicating either unusual cold-resisting qualities or a tendency to become perennial, was noted both at Fargo, N. Dak., and at Oakland, Nebr. In both of these cases the new type has the best stand remaining of all the 20 or 21 strains used in the experiment; in fact, at Oakland, No. 16 is the only plat on the field that has a full stand.

In a report dated June 25, 1906, just received from Mr. John P. Young, he states that with the exception of Russian clover No. 16 all of the plats have but a light sprinkling of plants from the old seed, and he is of the opinion that the majority of these were produced from seed matured in the autumn of the seeding year 1904. On a large portion of the field not more than one or two plants appear on 10 square feet of ground. Returning again to the Orel clover, Mr. Young refers to its upright habit, abundant foliage, soft velvety texture, and the preference that cattle show for it, and states that "it is the only strain on the whole field that has a full stand from the first seeding."

This tendency to become perennial, the absence of hairiness, and the other desirable qualities mentioned by Mr. Young continue to distinguish the new form from the ordinary type of red clover now in use.

SUMMARY.

Red clover, on account of its great value as a forage plant and because of its power of renewing and maintaining the fertility of the soil, is one of the most important crop plants of modern agriculture.

In the course of an extensive experiment with seed from different sources there appeared a variety, hitherto not used in the United States, possessing certain advantageous qualities which make it desirable to introduce it into American farming.

The seed of this variety was secured from the "Black Earth" region in the eastern part of the Orel government of Russia. The soil and climate of this section resemble strikingly those of our own northwestern prairie country, particularly Nebraska, Minnesota, and the Dakotas.

This variety is distinguished by the dustlessness of its hay, due to almost complete absence of hairiness from all parts of the plant, by its heavy yields for the first crop, by its leafiness and the persistence of the basal leaves, by the succulence of the stems, which improves greatly the quality of the hay and reduces the waste due to woody, uneatable portions, by greater palatability than hay from domestic seed, and by the fact that it comes to proper maturity for harvesting from ten days to two weeks later than the ordinary American red clover.

Except in certain sections and for certain purposes this variety is not recommended for supplanting domestic red clover, but rather for supplementing the latter.

Although the hairless Orel clover can be readily distinguished from the American form on the field, there is no apparent difference in the seed. The Department of Agriculture has at the present time no seed for general distribution, the supply on hand being sufficient only for purposes of experimental propagation.

Before purchasing seed from foreign sources, purporting to be of this variety, farmers are urged to take special precautions against the introduction of dangerous weed pests and to assure themselves as far as possible as to the genuineness of the seed.

PLATES.

DESCRIPTION OF PLATES.

PLATE I. *Frontispiece.* Fig. 1.—Plant of hairless Orel clover, almost mature. Fig. 2.—Mature plant of American red clover.

A portion of the plant from which figure 1 was made has been deposited in the United States National Herbarium (No. 409983) as a type specimen of *Trifolium pratense* var. *foliosum*. Formalin material from the same plant is preserved in the Laboratory of Plant Life History.

PLATE II. Fig. 1.—Stems, stipules, and bases of petioles of American and of hairless Orel clover (1½ times natural size). Fig. 2.—Young plants of hairless Orel clover and American red clover, showing smooth and hairy types (five-eighths natural size).

The photographs from which Plates I and II were made are of seventeen-months-old plants of the second crop, grown on the farm of the Minnesota Experiment Station, at St. Anthony Park.

PLATE III. Fig. 1.—Large plats used in clover experiments, North Dakota Agricultural College, Agricultural College, N. Dak. (Negative by O. O. Churchill.) Fig. 2.—Small plats used in experimental work, Ontario Agricultural College and Experiment Station, Guelph, Ontario. (Photograph furnished by Prof. C. A. Zavitz.)

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FIG. 1.—STEMS, STIPULES, AND BASES OF PETIOLES OF AMERICAN AND OF HAIRLESS OREL CLOVER. (ONE AND ONE-HALF TIMES NATURAL SIZE.)

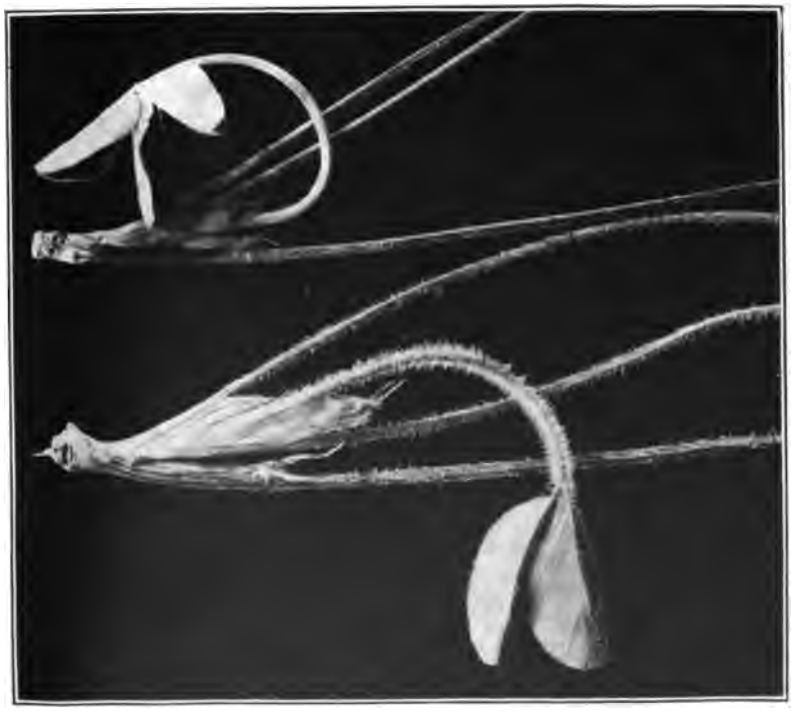

FIG. 2.—YOUNG PLANTS OF HAIRLESS OREL CLOVER AND AMERICAN RED CLOVER, SHOWING SMOOTH AND HAIRY TYPES. (FIVE-EIGHTHS NATURAL SIZE.)

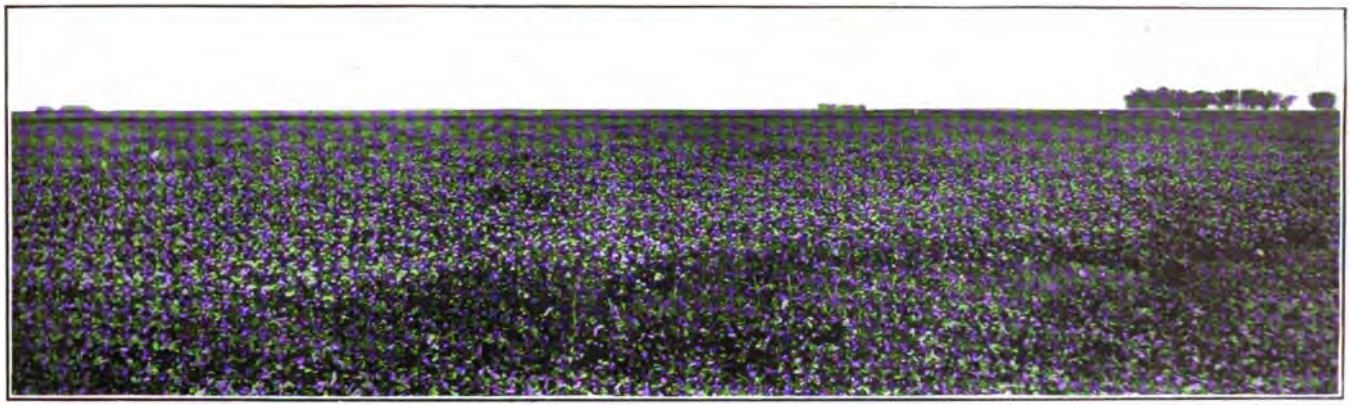

FIG. 1.—LARGE PLATS USED IN CLOVER EXPERIMENTS, NORTH DAKOTA AGRICULTURAL COLLEGE.

FIG. 2.—SMALL PLATS USED IN EXPERIMENTAL WORK, ONTARIO AGRICULTURAL COLLEGE AND EXPERIMENT STATION, GUELPH CANADA.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 99.

B. T. GALLOWAY, *Chief of Bureau.*

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MUSEUMS

TOBACCO BREEDING.

BY

A. D. SHAMEL

AND

W. W. COBEY,

IN CHARGE OF TOBACCO BREEDING EXPERIMENTS,
PLANT BREEDING INVESTIGATIONS.

ISSUED MARCH 12, 1907.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., September 25, 1906.

SIR: I have the honor to transmit herewith a paper on "Tobacco Breeding," by Messrs. A. D. Shamel and W. W. Cobey, of the Plant Breeding Investigations of this Bureau, and would recommend its publication as Bulletin No. 96 of the Bureau series.

The tobacco-breeding work of the Bureau of Plant Industry has now been under way for several years, and results have been obtained which have attracted widespread attention and proved of very great value to practical tobacco growers. This bulletin is intended to summarize the results secured up to date and to place the knowledge obtained before growers in such a form that they will be able to understand it and apply it in the practical work of improving their crops. The experiments have shown that tobacco can be improved in many important ways, and the methods by which such improvements can be produced are here described in detail. The illustrations form a very important part of the publication and are necessary to enable the grower to understand clearly the character and improvements discussed in the text of the bulletin.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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TOBACCO BREEDING.

INTRODUCTION.

The growing importance of the tobacco industry may be realized from a brief summary of the estimates of the value of the crop in the United States in the season of 1906. About 796,099 acres of tobacco were grown, producing an average yield of 857.2 pounds to the acre, or a total of 682,428,530 pounds. The average value of the crop was 10.0 cents a pound, or a total of about $68,232,647. While it is almost impossible to comprehend the magnitude of the value of the manufactured products of tobacco, a glance at the total figures may convey some idea of the development of this great and distinctively American industry. In 1900 the total value of the manufactured products of tobacco was $283,076,546. These products may be divided into three general classes, of which the values were as follows: Cigars and cigarettes, $160,223,152; chewing, smoking, and snuff products $103,754,362; stemmed and rehandled tobacco, $19,099,032. In the manufacture of these products 142,277 people were employed, who earned a total wage of $49,852,484. In addition to the tobacco grown in the United States there was imported into the United States in the year ended June 30, 1906, $4,143,192 worth of tobacco in a manufactured condition and $22,447,514 worth of unmanufactured products, making the total value of the importations during this period $26,590,706. During the same time the exports of manufactured tobacco were valued at $5,410,480, and of unmanufactured tobacco at $28,808,367. In 1891 the tobacco industry furnished almost $50,000,000 revenue to the Federal Government, and the revenue from this source now amounts to about one-eighth of the Government's total net receipts.

The United States now grows by far the largest quantity of tobacco produced by any country in the world. While tobacco was grown by the first settlers in the colonies and was one of their principal cash crops, the extensive development of this industry has been a matter of comparatively recent years. The introduction of tobacco into the different sections of the United States, with their widely varying

conditions of soil and climate, has resulted in the production of types adapted to the soils and conditions of these sections, as well as supplying a product for the varied manufactures now demanded by the consumers of tobacco. Improvements in methods of culture, curing, and fermentation have resulted in the production of tobacco having an increased value, but the most important factor in the development of more valuable tobaccos has been the production of improved varieties by seed selection and breeding. The production of these improved varieties adapted to local soil and climatic conditions has made possible the rapid development of the industry and enabled the United States in a comparatively short time to rank as the foremost tobacco-producing country in the world.

The prosperity of the tobacco industry as a whole and of the growers in particular depends on the development of improved varieties of tobacco adapted to the demands of manufacturers and consumers. There is no crop which responds so readily to breeding as tobacco, as has been proved by the experiments of the writers, and it is further true that without careful selection and breeding there is no crop which so quickly deteriorates in yield and quality. The extent of the areas in the United States in which the conditions of soil and climate are suitable to tobacco culture is almost unlimited, so that it seems possible that by giving attention to the production of varieties adapted to those conditions this country can continue to produce an increasingly large yield of valuable tobaccos.

The experiments of the writers have shown that it is possible to increase the yield and improve the quality of the crop by seed selection and breeding. The methods of breeding worked out in the course of these experiments are simple and practical and can be carried out by every grower with little or no extra cost in the production of the crop. The fact that tobacco is perfectly self-fertile and that self-fertilized seed produces more uniform and better developed plants than seed resulting from cross-fertilization within the variety makes it possible by the adoption of proper methods of saving seed to make rapid progress in the improvement of the crop. Improvement in the shape, size, and quality of leaves or increase in the number of leaves borne by the individual plants, all of which can be attained by breeding, means increased profits to the growers and manufacturers, and therefore is of vital interest to all who are interested in the production, manufacture, and consumption of this crop.

The production of new varieties of tobacco by hybridization and selection is a most important phase of tobacco breeding. The new hybrids of native New England varieties with standard foreign-grown varieties, combining certain valuable characters of both par-

ents, described in this bulletin, are good illustrations of the use of breeding in the improvement of the tobacco crop. The making and testing of hybrids are matters of experiment and require considerable time and expense, but experience has shown that the results justify the necessary expenditure.

The production of improved breeds of live stock and varieties of fruits and cereals, in fact, of all crops, might be cited to prove the importance of applying the principles of breeding to the tobacco crop. It is only recently that systematic breeding experiments have been undertaken. It is hoped that the results of the experiments cited in this bulletin will serve as a means of creating general interest in this subject and of inducing investigators, breeders, and growers to turn their attention to the further improvement of their crops.

Tobacco growers in the sections where these experiments have been carried on have generally adopted the improved methods of bagging carefully selected seed plants and of separating the seed, and they are using the improved varieties of tobacco produced in the course of these investigations. In most of these districts certain men have become interested in the careful and systematic breeding of tobacco.

THE GREAT VARIABILITY OF TOBACCO PLANTS.

Under the intensive system of cultivation necessary for the production of profitable crops of tobacco, the condition of the soil, the fertilization, and the cultivation are fairly uniform so far as individual fields are concerned. In those tobacco-growing sections where the best grades are produced it is a common practise to grow tobacco year after year on the same field without rotation, instances being known where more than fifty consecutive crops have been produced on the same field. This system of cropping enables the growers to become thoroly familiar with the character of the soil in all sections of the fields, so that any inequality in fertility can be remedied by the judicious application of manures or commercial fertilizers, or by methods of cultivation. Notwithstanding these favorable circumstances for the production of uniform plants, a careful study of the plants in these fields reveals a great lack of uniformity as regards all characters. This lack of uniformity is particularly noticeable with respect to the variation in number, size, venation, shape, and habit of growth of the leaves borne by individual plants, the time of ripening of the leaves on the same plant and on different plants, the number and size of the suckers, and the structure and arrangement of the flowers and flower heads. From the practical standpoint, there is no more important problem in tobacco culture than the production of uniform crops. A lack of uniformity in the

crop not only results in a low yield, as a whole, and more especially of the best and most profitable grades of the cured and fermented product, but also increases the cost of sorting out the different types of leaves into their respective grades for market, the expense of which must be borne directly or indirectly by the grower.

The principal cause of the lack of uniformity in tobacco is cross-fertilization. In tobacco, as in all other crops, seed resulting from cross-fertilization produces many plants unlike either parent. Therefore such seed is undesirable for the general planting of a crop where uniformity is so important a factor. Where the tobacco seed plants are grown without protection from cross-fertilization some of the flowers are cross-fertilized by insects or other agencies. Desirable plants may thus be crossed with undesirable plants in the same field or in adjoining fields, and the plants grown from the seed thus produced are usually extremely variable, some of them resembling the desirable plants from which the seed was harvested, others resembling the inferior plants from which the pollen was carried for crossing, while the remainder are of an intermediate type, unsuited to the purpose for which the crop is grown, and therefore causing a loss to the grower. The writers have observed numberless cases in different tobacco-growing sections where several distinct and worthless new types appeared in the fields, the plants of which were grown from carefully selected seed. These undesirable types could only be accounted for by the accidental crossing of the seed plants the year preceding or at some previous time. The crossing of individual plants of the same strain, even if both are desirable plants, results in undesirable variations, many of which are apparently reversions to earlier and unimproved types of tobacco.

In those varieties of tobacco in which the buds are removed long before the flowers open on all of the plants except those saved for seed production, or where early topping is practised, the opportunity for the crossing of the flowers borne by the seed plants with other plants in the same field is almost wholly limited to the seed plants. However, it frequently occurs that late or diseased plants, or possibly sucker branches that have been overlookt, develop flowers which open at just the right time to allow insects to carry the pollen from these flowers to the seed plants and thus effect cross-fertilization. There is little doubt that many of the plants of irregular and unusual types are produced as a result of this kind of cross-fertilization.

An important cause of variation in tobacco plants is the use of immature seed. Many growers cut off or harvest the seed heads before all of the seed pods have turned brown; hence, before maturity. The writers have observed hundreds of instances where the

seed plants have been cut off while many of the flowers were still in bloom. On such seed heads seed pods in all stages of maturity can be found. Some of the pods are fully ripe and contain mature seed, while others have not fully developed. Much of the seed is immature and contains little food for the nourishment of the plantlet. These seed heads are frequently thrashed out with a flail or the pods are crushed by the hands in order to shell out the seed. In this way the immature seed is mixt with the ripe seed sown in the seed beds. In the seed beds the immature seed frequently sprouts earlier than the mature seed, and the early seedlings grown from such seed are naturally used for transplanting in the field. Such plants have a great tendency to vary, in some cases being very early, and as a rule having leaves that are small, coarse, and wholly undesirable for any purpose. These weak, immature tobacco seeds, according to careful and extensive observations by the writers, produce plants which are more subject to certain diseases, particularly the mosaic disease, than are plants grown from mature seed.

The excess of plant food in the soil where heavy applications of barnyard manure and commercial fertilizers are used is usually thought to produce variations in the plants. This variation is usually shown by an increase in the size of the leaves, which is generally correlated with changes in color, flavor, and other characters. In these cases there is usually a tendency for the type of plant to break up, so that the uniformity of the crop is disturbed. Where it is necessary to use large quantities of fertilizers in the growing of a profitable crop, the inclination to variation induced by this intensive system of cultivation must be controlled by the most rigid selection of seed from the type of plants best adapted for the purpose for which the tobacco is grown.

The change of soil and climatic conditions, particularly the taking of tobacco seed from southern or tropical conditions to the north, is a fertile source of variations in tobacco. The fixation of a uniform type in this case requires several years of acclimatization, supplemented by selection of seed from the desirable plants.

In the production of improved varieties of tobacco by breeding, variation in type can be secured by crossing, and by continued saving of self-fertilized seeds from plants most nearly reaching the growers' ideal of perfect plants uniform types can be fixt. Growers will frequently find plants that are markedly better than the rest of the plants in the field, so that by selecting these desirable variations a steady improvement in the yield and quality of the crop can be effected. Variation, therefore, is a basis for selection in an experimental way, but in practise every effort must be put forth in order to secure uni-

formity of the plants in the field and thus produce the most profitable crops.

The variations in tobacco plants may be divided into two general classes—variation in type and individual variability within the type. The causes of the variations in type, or striking variations, include crossing and change of soil and climatic conditions, particularly the change of seed from the Tropics to temperate regions. The causes of individual variations within the type include the fortuitous variations or inherent tendency to variability, methods of soil fertilization and cultivation, maturity of seed, and various local conditions. With an understanding of these conditions the grower can to a great extent control the degree of variability by methods of saving seed, systems of cultivation, and other practical methods of culture.

THE INTRODUCTION AND ACCLIMATIZATION OF VARIETIES.

The introduction of the seed of standard foreign-grown varieties of tobacco has been the source of increased wealth and prosperity in certain tobacco districts of the United States. In other regions such importations have resulted in great financial loss to the growers, which in most cases has been due to a lack of knowledge of the effect of the change of soil and climatic conditions on the particular type of tobacco grown. The writers have had an unusual opportunity in the course of their work to observe the behavior of crops grown in different tobacco-growing sections from imported seed, and have conducted extensive experiments in taking seed from one district to another, with a view to securing definite information on this subject for the benefit of the growers. The results of these observations are presented here for the guidance of tobacco growers who desire to use foreign-grown seed or who wish to change their seed.

The western Florida and southern Georgia Sumatra tobacco industry is an illustration of the successful introduction of a foreign-grown variety of tobacco. Tobacco growers in this region secured small samples of the seed of the Sumatra variety of tobacco from the island of Sumatra. At first small experimental crops were grown and seed saved from the best plants in these crops. In the course of this experimental cultivation it was noticed that the plants grown under the partial shade of trees in freshly cleared fields produced finer and more desirable leaves for cigar wrappers than the plants grown in the open. This fact led to the erection of an artificial shade over the fields, made of slats laid on a suitable framework. This method of growing tobacco was introduced about 1896 by Mr. D. A. Shaw, of Quincy, Fla. Later, other growers

used a coarse cheese cloth as a substitute for the slats. The shade method of growing tobacco in this region has developed rapidly, and at the present time several thousands of acres of tobacco are grown under either slat or cloth shade, and the industry has become established on a profitable and successful basis. During this time considerable attention has been paid to the production of a uniform type of tobacco adapted to the climatic and soil conditions of this section by the saving of seed from carefully selected plants of the Sumatra variety.

When Sumatra seed was first introduced into Florida the variety broke up into a number of different types, some of which were desirable, while others were undesirable. By reason of the small crops grown from such seed, the loss to the growers from the production of undesirable types of plants was not very great. The growers naturally saved for seed those plants which produced the most desirable types of tobacco, and as a result of continued selection of this kind a fairly uniform type of tobacco which was adapted to the local conditions in this section was secured. As the demand for this Florida-grown Sumatra tobacco developed, resulting in increased acreages, seed was at hand which was thoroly acclimatized for planting the larger area devoted to this crop. From time to time the tobacco planters in this region have obtained small quantities of seed from Sumatra, but in such cases this seed has been grown in a very limited way in very small fields until it has been acclimatized and uniform types have been secured by seed selection.

About the time of the Cuban revolution it became apparent that the supply of Cuban-grown tobacco for the use of cigar manufacturers in the United States might become limited by reason of the unfavorable conditions for tobacco growing then prevailing in Cuba. Under these circumstances it was thought to be a propitious time to introduce the growing of Cuban tobacco into southern Florida, where the conditions of climate and soil were believed to be similar to those of Cuba. Considerable public interest was aroused in this project, and as a result large quantities of Cuban-grown seed were secured and planted in certain sections of Florida. The crops raised from this seed proved to be a disappointment to the growers. The change of soil and climatic conditions resulted in the breaking up of the type of the Cuban variety into a large number of sorts, some of which were desirable, while others were undesirable. Many of the plants developed a branching habit of growth, bearing very small, undesirable leaves of poor quality, resulting in a very low yield of an inferior tobacco. One of the main causes of failure was the lack of understanding on the part of the growers of the effect of the change of conditions on the type of tobacco and their

neglect to appreciate the necessity of securing strains of plants by seed selection of the desirable types adapted to the particular conditions of soil and climate in southern Florida. If the acclimatization of these strains had been accomplished by seed selection in small fields, with little loss to the growers, the strains could have been grown on a more extensive scale with better chances of success.

In order to illustrate the necessity for the acclimatization of a variety of tobacco before it is grown on an extensive scale, the successful experiments of the Bureau of Soils in the introduction of Cuban tobacco in Texas may be cited. After a previous unsuccessful attempt by farmers in Texas to grow Cuban tobacco from freshly imported Cuban seed the Bureau of Soils began systematic experiments in growing small fields of tobacco and saving the seed of the most desirable plants according to the method described in this bulletin. In these crops certain plants were found which produced leaves possessing the flavor and aroma desired in a high-grade filler tobacco. The seeds from these plants were saved under bag, and their product has been found to possess the desirable characters of the parent plants. This tobacco has been sold at profitable prices, and the area devoted to the growing of this crop is being gradually extended in order to meet the demands of the manufacturers for this grade of filler tobacco. In northern Florida the tobacco growers, as a result of their experience with the imported Sumatra seed, experimented in growing, in the open, small fields of a cigar filler tobacco of a variety the seed of which was originally introduced from Cuba. This variety of Florida filler tobacco is now being grown extensively and profitably in that section.

The best illustration of the effect of a change of climatic and soil conditions upon the character of a variety of tobacco is found in the experience of tobacco growers in the Connecticut Valley in the planting of Florida-grown Sumatra seed and seed of the Sumatra variety imported from the island of Sumatra. As discust in an article upon the improvement of tobacco by breeding and seed selection in the Yearbook of the Department of Agriculture for 1904,[a] tobacco growers in the Connecticut Valley in the seasons of 1901 and 1902 grew extensive crops from seed introduced from Florida and Sumatra. In a careful examination of these fields it was found that the change in conditions had resulted in the breaking up of the type of the variety, so that several distinct types of tobacco were found growing in the same fields. Some of these types of plants produced well-rounded leaves, with fine venation and the elasticity, strength, gloss, grain, and other characters necessary in

[a] Shamel, A. D. Yearbook of the Department of Agriculture, 1904, pp. 435–452.

a high-grade cigar wrapper tobacco. However, many of the types of plants produced long, narrow, coarse, pointed leaves, wholly unsuited for cigar wrapper manufacture. In the case of another inferior type it was found that the leaves would not burn, altho the remaining characters were those of a desirable grade of tobacco. It was impossible to sort out this type, even by the most careful inspection of the crop, and, as a result, when the manufacturers wrapt cigars with leaves of this type and found that the wrapper would not burn, the quality of the entire crop was condemned. Certain other types of plants produced leaves of such thin texture or light body that when wrapt on cigars and allowed to dry out the wrapper frequently broke, or when the consumer carried the cigars in his pocket the wrappers were easily injured.

FIG. 1.—Belgian type of Connecticut Sumatra tobacco plant. These long, narrow leaves with oblique veins, coarse texture, burn very poorly, and after curing light green color are almost absolutely worthless for cigar-wrapper purposes. This type appeared in crops grown in the Connecticut Valley from Florida-grown Sumatra seed.

One of the most striking types of plants produced in the crops grown from this imported seed was the Belgian type, an illustration of which is shown in figure 1. In this case the plants bore leaves measuring from 30 to 46 inches long and only from 5 to 10 inches wide. These leaves, as shown in figure 2, were very pointed in shape, with coarse, angular veins, and as the cured tobacco lacked the appearance necessary for a cigar-wrapper tobacco its production was a total loss to the growers. The variation in type was accompanied by differences in time of maturity, so that the cost of the growing and harvesting of these crops was greater than in the case of uniform crops. The mixture of types was accompanied by great variation as regards the individual plants of each type. In many cases plants bearing 25 leaves were found growing by the side of plants producing 10 leaves. Marked variations in size and shape of leaves and in the number of suckers borne by the individual plants were observed; and as a result it was found that the comparatively small number of desirable types could not make up for the loss in the production of undesirable and worthless grades of tobacco. As a natural consequence of this condition the extensive culture of this variety of tobacco from imported seed has been abandoned, and the grow-

ers now have small fields and are selecting those plants producing the most desirable grade of cigar-wrapper tobacco with a view to securing strains which are adapted to the conditions of the Connecticut Valley. In the experimental fields of the Bureau of Plant Industry, covered with cloth shade, where seed of desirable plants has been saved under bag for three seasons, uniform strains, which are absolutely free from the unusual or distinct types observed in the fields from which the original selections of seed were made, have been produced.

FIG. 2.—Typical leaf of Belgian type of tobacco, showing the characteristic shape, venation, and other characters of this variety which are wholly unsuited for cigar-wrapper manufacture. The presence of such types of leaves reduces the value of the crop and is detrimental to the reputation of the variety of tobacco in which they are produced.

A few of the growers of the Sumatra variety in the Connecticut Valley introduced Cuban-grown seed and used it for planting their general crops. In these fields the breaking up in type was not so noticeable as in the case of the Sumatra variety, but the effect of change of conditions in the variety was shown in the production of so-called freak plants. These plants had a branching, or suckering, habit of growth, bearing very small, sharply pointed, coarse leaves that were worthless for cigar-wrapper purposes. In a careful study of the plants in these fields it was found that at least one-third of the entire crop consisted of these freak plants.

In one of these fields the writers made selections of seed plants of the most desired type, bearing the size, shape, and general character of leaves adapted for cigar wrappers. This seed was saved under bag, and a similar plan has been followed up to the present time.

In Plate I, figure 1, the original crop raised from freshly imported seed from which the seed selections were made is shown. In Plate I, figure 2, is shown a crop grown on the same field after two generations during which the seed was saved under bag. As can be seen from the illustrations, this method of seed selection and bagging has produced a uniform type of tobacco without the freaks and other undesirable types of the original crop. It is fortunate that on this farm the planter saved seed in the open for his own use from the same field. The crop grown from such seed was visited during the season of 1905 by the writers, in company with Dr. H. J. Webber and several tobacco growers, and was found to contain a large proportion of freaks; in fact, about the same proportion as the crop grown from

freshly imported seed. In other words, the seed saved under bag produced uniform strains adapted to soil and climatic conditions in this section, while seed saved in the open and subject to cross-fertilization with freaks and other undesirable types produced about the same proportion of freak plants as the crops grown from the freshly imported seed.

The writers during the past season planted in Florida Connecticut-grown seed of the Sumatra variety. It was found that while there was a noticeable change in the shape of leaf and in some minor characters in the Florida-grown tobacco, there was no violent breaking up of type or indication of unusual variability. This experiment and other observations have led the writers to believe that the effect of changing seed from the north to the south is not accompanied by such marked changes as when seed is taken from tropical conditions to northern latitudes.

In summing up the observations on this subject it can safely be said that it is a dangerous policy to plant large crops of tobacco with imported seed or with seed from a very different section. In most cases it has resulted in failure and caused considerable loss to the growers. The general crops should be planted from seed produced under the same conditions as the crop which is to be grown. If it is necessary to change the seed or desirable to test imported varieties, it should be done on a small scale, followed by a most careful selection of seed plants, and the seed should be saved under bag, safe from cross-fertilization.

THE STRUCTURE AND ARRANGEMENT OF FLOWERS.

A careful study of the tobacco flower is one of the most essential factors in the beginning of tobacco breeding. Successful results, particularly in the production of new varieties, can seldom be obtained until one becomes familiar with the structure of the parts of the flower and the manner in which these parts perform their several functions. A full realization of the ease with which crossing takes place can only be obtained in this way, and, as has been previously stated, the prevention of promiscuous cross-pollination is of first importance in the production of a desirable and uniform type of tobacco.

The tobacco flowers are arranged upon a branching determinate flower head, which appears when the middle leaves are about half grown and continues to develop and produce new flowers during the rest of the life of the plant. Figure 3 is a diagrammatic sketch of a tobacco flower, showing the parts of the flower and the general way in which pollination takes place. The calyx (*a*) is the outer, green, five-parted, floral envelop at the base of the flower which serves to

protect the flower in the bud. The corolla (*b*) is the delicately colored floral envelop inclosing the reproductive organs of the flower. Its color tends to attract insects, which are the principal agents in cross-pollination. Next inside the corolla are the five stamens, which are the male reproductive organs of the flower. Each stamen consists of the filament (*i*), supporting the anther (*j*) in which the pollen grains (*k*) are produced. The central organ is the pistil, or female part of the flower. The terminal enlarged portion (*g*) is the stigma. The pollen grains (*k*) adhere to the surface of the stigma (*g*) and germinate, sending an extremely minute tube (*l*) down thru the central conductive tissue (*h*) of the style (*f*). This tube extends into the cavity of the ovary (*d*) and finds its way into the ovule (*n*) thru a small duct or micropyle (*m*), where fertilization takes place. Other ovules (*e*) are fertilized by other pollen tubes. These ovules develop into seeds after fertilization. The ovary is two-celled, with a fleshy central placenta (*c*) on which the ovules are borne. The early capsules mature always before flowering ceases. The shape of the delicately colored corolla is somewhat tubular, or, perhaps, more nearly like an elongated funnel. It is comparatively small from the basal end to a point about two-thirds the distance to the terminal end of the flower. At this point it enlarges suddenly to more than twice the size of the basal part of the tube (fig. 3). It is composed of 5 petals, which coalesce to form the corolla tube, and separate only at the extreme end.

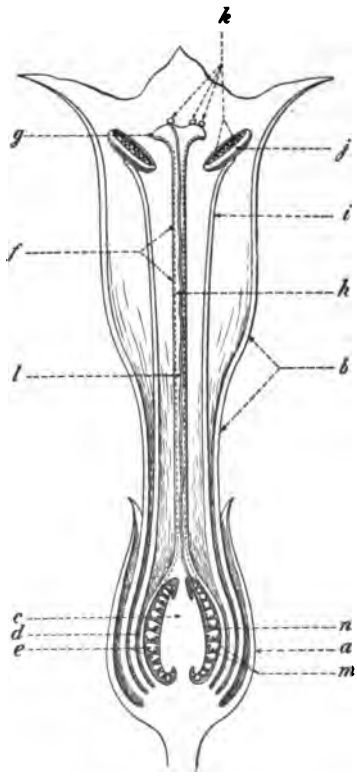

FIG. 3.—Diagrammatic sketch of tobacco flower.

The tobacco flower is symmetrical. The number of sepals and stamens is always the same as the number of petals, but these floral circles do not remain constant, varying rather indefinitely in different strains and even among individuals of the same strain. Trimerous flowers, or flowers with three parts in each flower circle, have been found growing on the same plants with pentamerous flowers, or those having five floral parts. This is the exception, however, and not the rule.

The tobacco flower is naturally self-fertile, and plants grown from

self-fertilized seed are always stronger and more vigorous than those from cross-pollinated seed when the crossing is within the variety. In Sprengel's discourse on the cross and self pollination of plants the statement is found that "nature seems to have wished that no flower should be fertilized by its own pollen." Later, Darwin stated that "nature abhors perpetual self-fertilization," but, unlike Sprengel, recorded a number of exceptions to this rule, and tobacco was among them. The experiments of the writers conclusively substantiate the findings of Darwin in this connection. They have found self-pollination in the case of tobacco to be most desirable in all cases.

A very interesting phenomenon of growth takes place in the filaments of the stamens immediately after the opening of the flowers, which can be taken as an evidence of the natural self-fertilizing habits of the plants. An examination of the flower just previous to the time of opening will reveal the fact that the pistil is longer and extends up beyond the stamens, but when the anthers open and the stigma becomes receptive a very rapid growth of the filaments takes place, which causes the open pollen sacks to be pushed up past the stigma, and in almost all cases they come in direct contact with the stigma in passing upward. This gives an opportunity for at least a portion of the pollen grains to adhere to the viscous surface of the stigma and for self-fertilization to take place, as shown in figure 3. It is just before this process occurs or while it is in progress that there is danger of, or opportunity for, cross-pollination. The open flower contains a small drop of nectar at the base of the corolla tube, which is sought by honeybees, bumblebees, and humming birds, as well as by many species of minute insects, all of which carry pollen from flower to flower and from plant to plant in their constant search for the honey-like substance secreted in the corolla tube. In passing in and out of the flowers the bodies of the bees and other insects and the beaks of the humming birds become dusted with pollen, which is transported by them to the pistils of the next flower visited. The ovules are as readily fertilized by pollen from the surrounding plants as by the pollen from the flower in which they are produced. This continuous crossing necessarily results in the introduction and intermixture of poor and undesirable varieties in our best strains of tobacco.

The observations of the writers plainly show the absolute necessity for protecting the flowers of the seed plants from cross-pollination. Careful experiments have demonstrated that in many instances the stigma of the tobacco flower remains in a receptive condition for three or four days. This condition results in a twofold disadvantage when no protection is used against cross-pollination. In the first place, it affords abundant time and opportunity for complicated

crossing, for each flower is visited many times a day by various insects and often by humming birds; and, secondly, it brings about conditions favorable for the production of seed of weak vitality. Previous experimenters have pointed out the fact that the best seed is not produced as a result of premature or late pollination, either of which is likely to occur in the case of tobacco flowers under natural conditions. When fertilized only by pollen of the same flower, the pollination takes place at exactly the right time, or when the stamens push past the receptive stigma, which results in the production of a superior grade of seed.

The readiness with which tobacco flowers can be cross-fertilized greatly facilitates the opportunity for producing new and valuable varieties by artificial crossing. In the course of the experiments here recorded it has been found perfectly possible to combine certain desirable qualities found in different strains and at the same time to eliminate some of the undesirable characters by producing hybrids between strains of tobacco.

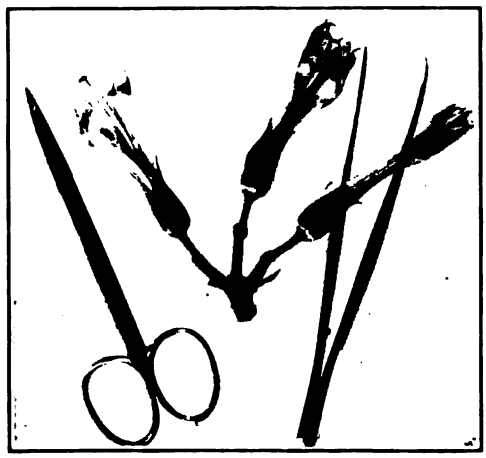

FIG. 4.—Three tobacco flowers at proper stage for emasculation, and the scissors and forceps used in emasculating flowers. The corolla of the central flower has been opened in order that the anthers may be conveniently removed. The flower on the left has been emasculated preparatory to cross-pollination.

The method of cross-pollination used in the experiments of the writers is to remove all capsules, open flowers, and flower buds from the flower head except those which are in the proper stage of development to open within the following twelve or fifteen hours. In preparing these remaining flowers they must be carefully opened and emasculated by the use of a scalpel, small scissors, and a fine pair of forceps, as illustrated in figure 4. Great care must be taken in removing the anthers before they have dehisced, in order to avoid injury to the stigma. The emasculation should be done in the afternoon, after which all of the flowers must be carefully covered with a thin paper bag as a protection against insects or other agencies whereby pollen might be transferred to them. In the forenoon of the following day the emasculated flowers should be ready for pollination, but the exact time for applying the pollen must be determined in the case of each individual flower by the appearance of the viscid, sticky fluid on the surface of the stigma. The pollen from the male

parent plant can be best applied to the stigma of the female with the point of a scalpel or other sharp instrument. When applied with a brush there is danger of some of the pollen grains adhering to the hairs of the brush after each operation, resulting in considerable mixture of pollen, but where the scalpel is used there is no difficulty in removing all the pollen after each operation. The paper bag must be replaced over the flowers as soon as they have been pollinated, and must be allowed to remain until the seeds have set and all danger of crossing has past.

In crossing it is not essential that both of the parent varieties be grown in the same community. Pollen from tobacco flowers when thoroly dry will keep for several weeks or longer without deterioration. The writers have sent pollen thru the mails a distance of more than a thousand miles with perfectly satisfactory results. When not intended for immediate use, it should be harvested when perfectly dry and carefully taken off the anthers after they have dehisced and become dried out. These dry anthers may be put in small vials, and the pollen kept long enough for all practical purposes, provided the vials are carefully corked and kept dry.

The large number of seed produced in a single pod and on a single plant makes it possible to obtain definite results from selection or hybridization in tobacco much more quickly than in the case of most other plants. Careful counts show that from 4,000 to 8,000 seeds are produced in a single pod of normal size, and an estimate of the average number of pods on each plant shows that the ordinary tobacco plant produces from 500,000 to 1,000,000 seeds. In many cases the writers have secured from 1 to 1½ ounces of seed from a single plant when the seed has been saved under bag according to the method outlined in this bulletin. This large number of seeds gives an excellent opportunity for testing each selection or cross on a large scale. The quantity of seed produced varies inversely with the number and size of leaves on the plant. The production of a large number of good-sized leaves is almost invariably accompanied by the production of a small quantity of seed.

On account of the large quantity of seed produced by a single plant under normal conditions and the fact that the various characters of a tobacco plant are inherited so strikingly and uniformly by its progeny the following year when the seed is saved under bag, protected from cross-fertilization, it is possible for the tobacco grower to secure uniformity with a considerable degree of improvement in type, quality, and yield by one year's selection. One plant often furnishes enough seed for an entire crop, and the plants raised from this seed always produce a very uniform lot of tobacco when cross-fertilization is not allowed to take place.

THE NECESSITY FOR INBREEDING.

In the season of 1903 the writers, in company with Dr. H. J. Webber, visited the tobacco fields of the Connecticut Valley in response to a request of the growers for assistance in the production of uniform strains of tobacco by breeding and seed selection. During the survey of this region with a view to gaining an idea of the variability of the varieties of tobacco, it was determined to inaugurate a series of experiments in a practical way for the investigation of the methods of saving seed.

In view of the results of the investigations of Darwin and others on the comparative vigor of growth, seed production, and other characters of tobacco plants raised from seed obtained by cross and by self fertilization [a] the seed of select plants of the different types of tobacco was protected from cross-fertilization by inclosing the flower heads with a light but strong form of paper bag. Other seed plants were saved without such protection, as is ordinarily done by the tobacco growers. The seed harvested from these seed plants was saved separately, stored in small glass vials adapted to this purpose, and labeled according to the system now in use by the breeders in the plant breeding investigations of the United States Department of Agriculture. The record of the number of leaves, size, thickness, shape, and color of leaves, number of suckers, height of plant, habit of growth of leaves and plants, time of maturity of leaves and seed, and other characters was kept according to the system used by Doctor Webber, modified by the writers for use in keeping a pedigree of tobacco varieties.

The seed of the plants finally selected for experimental purposes was sown in ordinary seed beds, separated into many small sections by thin board partitions, each of which was capable of holding 500 seedlings. The seedlings from these separate seed-bed plats were transplanted to separate rows or plats in the experimental field, each row or plat being carefully labeled so that the plants could be traced directly back to the original seed plants. The manuring, or fertilization, and preparation of the soil in the experimental field and the transplanting, cultivation, and harvesting of the plants were all conducted with the greatest possible care to give all of the rows or plats equal opportunity for growth. For instance, the seed of all of the plants of a variety was sown the same day, and at the proper time the seedlings of this variety were all transplanted the same day. At the time of harvest the leaves of the individual rows or plats were primed or the plants cut on the same day, and the leaves or plants were hung in the curing shed, so as to get as nearly uniform condi-

[a] Darwin, Charles. Cross and Self Fertilization in the Vegetable Kingdom. pp. 203–215.

tions for curing as were consistent with the practical handling of the crop. The leaves of plants selected for seed were harvested separately and labeled so that the product of each plant could be intelligently used in comparative tests of the cured and fermented crop. This labeling process involved considerable extra work and attention in the field, curing sheds, and warehouses, but was absolutely necessary for a definite selection of seed plants for the next season's use, based on the character of the fermented tobacco.

The rows or plats of plants grown from seed of individual plants saved under bag, i. e., self-fertilized seed, showed remarkable uniformity in type, size, shape, and appearance of leaves, habit of growth, and all other characters, and conformed closely to the type of the parent plants from which the seed was saved.

Plate II, figure 1, shows a type of parent plant and Plate II, figure 2, the progeny of this plant, raised from self-fertilized seed. From this illustration it can be seen that the transmitting power of tobacco is most strongly marked and the progeny of plants raised from inbred seed remarkably uniform in all characters, every plant closely resembling the parents. In the hundreds of tests of this character which have been carried on by the writers during the past three seasons, not only in the Connecticut Valley but in Maryland and Florida, the benefits to be derived from using inbred tobacco seed have been confirmed and emphasized. It is true that some plants have the power of transmitting their characters to their progeny more strongly than others, but on the whole every case under observation has offered additional evidence of the value of the practise of saving tobacco seed under bag, free from possible cross-fertilization.

The continued saving of self-fertilized seed for three seasons has furnished no evidence of a decrease in the rate of growth or constitutional vigor of tobacco plants as a result of this practise. On the other hand, by reason of the selection of the best plants in the different varieties every season there has been a marked increase in the productiveness and the general vigor of constitution of the varieties under consideration. This conclusion is emphasized by the vigorous and productive strains of Connecticut tobacco shown in Plate III.

Self-fertilization is the closest possible degree of inbreeding, and it is the general impression that this practise is usually associated with a loss of vigor of growth, with a predisposition to disease, and other undesirable results. In tobacco, so far as our experience goes, this does not happen, and the exact opposite of this condition obtains, viz, that inbreeding is beneficial to the general development of the variety.

It is unfortunate that it is impossible to present tabular data at

the present time showing the behavior of plants raised from artificially cross-fertilized seed within the variety in comparison with plants raised from self-fertilized seed. The principal object of this work has been the achievement of practical results, so that the opportunity for scientific observations and experiments has been necessarily limited. However, the writers have had the privilege of making careful observations on the results of saving seed from plants grown under large field tents and comparing the plants raised from such seed with the plants raised from self-fertilized seed. Under these tents there is little opportunity for cross-fertilization with other varieties, except thru the small doors opening into these tents, which are kept closed all of the time when persons or teams are not actually passing thru them, so that there is little likelihood of bees or other insects passing in and out. The probability is that the cross-fertilization that takes place is wholly between the plants saved for seed in these tents or with other plants under these shades that are in bloom at the proper time for cross-pollination.

The comparison of the plants raised from seed saved under these field tents and exposed to cross-fertilization with the surrounding plants and of plants of the same variety raised from seed protected from cross-fertilization by paper bags shows that self-fertilized seed produces more uniform, vigorous, and productive plants than the open-fertilized seed, which is to a greater or less extent cross-fertilized between plants of the same variety.

It appears that the cross-fertilization of tobacco seed, even tho it occurs between good individuals, has a tendency to seriously break up the type. Along with the variability of type induced by cross-fertilization, it frequently happens that many freak plants resembling the wild species appear; these can only be explained with our present knowledge of the subject as reversions. Such freak plants are not usable for profitable manufacture, and consequently are a source of loss to the growers.

The size and weight of seed from the inbred plants are equal to and in most cases greater than the seed saved from open-fertilized plants. In a series of comparative tests of the two kinds of seed in the case of four varieties grown in the Connecticut Valley it was found that the inbred seed was heavier and larger than the cross-fertilized seed. The total quantity of seed harvested from the open-fertilized plants usually exceeded that of the inbred plants. This was due to the fact that in the case of the inbred plants more of the seed-bearing branches were removed than where the plants were allowed to set seed under natural conditions, in order to adapt the seed head for the best possible development under the paper bags. Where an equal number of seed pods was examined for

yield of seed the inbred seed equaled or exceeded in quantity the cross-fertilized seed in the variety. In the case of hybrids or in the crossing of two distinct strains or varieties the yield of seed, as well as rate of growth of the hybrid plants, was greater than that of the inbred seed and plants. It is true that some of the improved inbred strains produce but little seed compared with unimproved types of the same variety. Inbred strains have been selected for increased yield and number of leaves, which seem to be correlated with lessened seed production. The same correlation holds true where open-fertilized strains have been selected for increased number and total yield of leaves.

The rate of germination of the inbred in comparison with the cross-fertilized seed was thought to be slower in some of the experiments carried on in the season of 1904. However, further comparisons have failed to bear out this conclusion, and it is the belief of the writers, based on careful observations on this subject, that the inbred seed sprouts as rapidly as the cross-fertilized seed. It seems probable that in the cases observed by growers in 1904 a difference in moisture content of the rotted apple-tree fiber, the medium used for sprouting, was the cause of the apparent differences in time of sprouting. So far as the writers' observations go, the inbred seed produces more rapidly growing plants than the open-fertilized seed, and consequently earlier plants for transplanting. There is no doubt, further, that the inbred seed produces a larger proportion of seedlings for transplanting at one time than the open-fertilized seed, which is an important matter to the tobacco grower, who is frequently forced to wait for seedlings on account of the lack of uniformity of plants in beds sown with open-fertilized seed.

Darwin's conclusions on the comparison of tobacco plants raised from inbred and cross-fertilized seed for three years are as follows:[a]

> Taking the plants of the three generations altogether, the crossed show no superiority over the self-fertilized, and I can account for this fact only by supposing that with this species, which is perfectly self-fertile without insect aid, most of the individuals are in the same condition as those of the same variety of the common pea and of a few other exotic plants which have been self-fertilized for many generations. In such cases a cross between two individuals does no good; nor does it in any case, unless the individuals differ in general constitution, either from so-called spontaneous variation or from their progenitors having been subjected to different conditions. I believe that this is the true explanation in the present instance, because, as we shall immediately see, the offspring of plants which did not profit at all by being crossed with a plant of the same stock profited to an extraordinary degree by a cross with a slightly different subvariety.

[a] Darwin, Charles. Cross and Self Fertilization in the Vegetable Kingdom, p. 210.

These conclusions of Darwin were based upon greenhouse and garden tests, where, of course, it was not possible to study and compare the characters of quality or the value of the tobacco from the inbred and cross-fertilized seed. The observations of the writers upon tobacco grown in the field under normal conditions in the different tobacco-growing sections bear out the conclusions of Darwin on this subject, and show, further, that the inbred seed produces more profitable crops of tobacco than the seed resulting from open or cross fertilization within the variety.

THE IMPROVEMENT OF THE SHAPE OF LEAVES.

The shape of the leaves is a very important factor in determining the value of all classes of tobacco, and is of first and particular importance in cigar-wrapper varieties. Many varieties which possess some of the most desirable characteristics of high-grade wrappers are totally valueless for this purpose on account of the narrowness of the leaves. From such leaves it is impossible to cut cigar wrappers economically. The manufacturer of cigars demands a leaf which is wide and well rounded at both ends. This shape admits of the best opportunity for cutting into wrappers of the desired shape and size with the least possible waste, while the long, pointed leaf will yield very few wrappers, and a very considerable proportion of it must be consigned to the waste pile.

The long, pointed leaf is not only undesirable because of its shape, but the texture toward the basal end is poorly adapted for cigar wrappers and the grain is usually unevenly distributed. In such cases a large part of each leaf can be utilized only for binders or low-grade fillers. A striking example of leaves of this character may be found in the case of many strains of Connecticut and of Pennsylvania Broadleaf varieties. When working these varieties the manufacturer expects to cut wrappers from the middle portion and tips of the leaves only, while the remainder of the leaves, often half or more, must be used as binders or for filler purposes. A wider leaf and one which is more nearly round would yield many more wrappers to the pound and would be proportionately more valuable.

In addition to being wide, with well-rounded tips, the best wrapper leaves must have small, fine veins which are widely separated and which form an obtuse or right angle with the midrib. The veins in narrow leaves extend along down the leaf toward the tip, are coarse, and present a very unattractive appearance when wrapt on cigars, while in the case of wide leaves the veins usually extend out toward the edge of the leaf and are almost perpendicular to the midrib, smaller in size, and wider apart. In some of the strains of

Broadleaf tobacco which have been improved by careful seed selection and breeding the veins are sufficiently wide apart to allow wrappers for cigars of standard size to be cut between the veins. Such wrappers have a very smooth, attractive appearance on cigars, and where they can be cut in this way the waste material from each leaf is exceedingly small. Figure 5 illustrates the superior value of the wide over the narrow form of leaf for cutting wrappers economically. Attention is also called to the character of venation

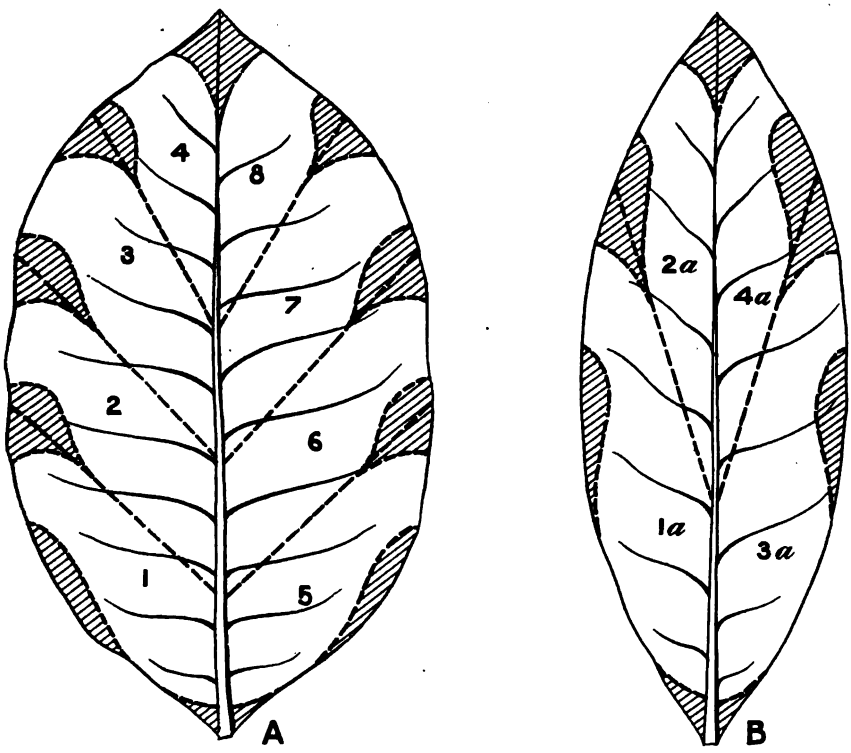

FIG. 5.—Diagrams showing the superiority of broad over narrow leaves for cigar-wrapper purposes: A, broad leaf; wrapper cuts numbered 1, 2, 3, 4, 5, 6, 7, and 8. B, narrow leaf; wrapper cuts numbered 1a, 2a, 3a, and 4a. Waste indicated by hatching. Not only do the broad, round leaves yield more cigar wrappers, but on account of the venation and other characters they produce wrappers of superior quality.

in the two leaves shown. It will be observed that the veins extend out almost directly toward the edge of the leaf from the midrib in the case of the wide leaf (A), while in the case of the narrow leaf (B) the veins run upward, and, consequently, when used as wrappers injuriously affect the appearance of cigars.

The variability of the plants in the field in respect to shape of leaf is found upon close observation to be more striking than the variability in many other characters. The variability of strains of

tobacco grown from the seed of the same variety and under similar conditions as respects shape of leaves is shown in Plate IV. It is very important that this variability be reduced to the minimum, and the writers have found that it is possible to greatly reduce the variability by systematic seed selection. Plants producing leaves which are very long and narrow are frequently found growing beside others with well-rounded leaves of a desirable length. Plants bearing leaves of the ideal cigar-wrapper shape and those that were totally worthless on account of their shape, as well as many gradations between these extremes, have been found growing side by side. In the case of a field of Florida tobacco grown from freshly imported Sumatra seed a similar variability was observed in the summer of 1905. The production of leaves of undesirable shape results in a direct loss to the grower and manufacturer alike. The cost of production to the grower is no greater where the leaves are all of uniform size and shape, and the cost of grading is greatly reduced.

In nearly all varieties of cigar-wrapper tobacco, most of the leaves are small and narrow near the basal end and this portion of the leaf is seldom wide enough for wrapper purposes. Figure 5, A, shows a leaf wide at both ends, from which wrappers may be cut down to the extreme basal end, thus avoiding the waste which can not be avoided in the form of leaf shown in figure 5, B. It is important to produce the form of leaf shown in figure 5, A, not only because it will yield more wrappers to the pound and necessitate very much less waste in cutting, but because more wrappers to the acre may be obtained.

The variability in the shape of leaves on the same plant is often very marked, and may be as readily corrected by proper methods of seed selection as the variation among the individual plants in the field. The size and shape of the individual leaves on almost all plants vary more or less, but on some much more than others. An occasional plant will be found on which the leaves are comparatively the same size and shape from the top to the bottom of the plant, while in other cases there are marked differences in this respect. Where this uniformity is found the top leaves are seldom as thick or heavy as where there is a lack of such uniformity, and therefore a larger percentage of the leaves is adapted for cigar-wrapper purposes.

By selecting for seed the plants possessing leaves of the most desirable shape from top to bottom and protecting them from cross-fertilization, it is possible to produce a crop which will be uniformly like the parent plant. It can be plainly seen that this will result in a larger yield to the acre of much more valuable tobacco because of the uniformly well-shaped leaves, best adapted to cigar-wrapper

purposes, and this may be accomplished with no additional expense to the grower.

The shape of the leaf in certain types of smoking tobacco largely determines its adaptability to both soil and market conditions. In Maryland it has been found generally true that a broad leaf gives best results on very light sandy soil, and is best adapted to the demands of the German market, while a somewhat narrower or longer leaf is more desirable on heavy clay soil; from this latter type the highest grades of red tobacco are produced to meet the requirements of the markets of France. In the case of Maryland tobaccos the shape of leaf is usually correlated with the number of leaves, there being more leaves to the plant where they are narrow than in cases where they are broad. The writers have observed many exceptions to this rule and have found that by keeping this point in mind when selecting seed plants it is possible to find round-leaved plants producing a large number of leaves, and to procure varieties from these plants which will produce a large number of uniform leaves and at the same time a grade of tobacco which will be adapted to the demands of the market for which it is grown.

It is within the power of the tobacco grower to produce the shape of leaf best adapted to the purposes for which his tobacco is grown, and to continually improve the shape and gradually bring it up to the ideal of a perfectly shaped leaf, by carefully selecting seed plants year after year which produce leaves most nearly approaching this ideal. In all cases if uniform types are to be produced cross-pollination must be prevented, in order that the progeny the following year may inherit only the characters of the desirable parent plants.

THE MODIFICATION OF THE SIZE OF LEAVES.

The modification and control of the size of tobacco leaves is of almost equal importance to the improvement of their shape, and the size is so intimately associated with the shape that both features can be dealt with along the same lines in the improvement of tobacco by breeding and seed selection.

The purpose for which the crop is grown must always determine the most desirable shape and size of the leaf, and the individual grower must decide for himself what size and shape will be best adapted to the local market demands. The importance of producing a comparatively definite and uniform size of leaf is well recognized by the manufacturers of all classes of tobacco. In the case of the Maryland Smoking tobacco grown for export purposes it is difficult to procure a leaf which is too large for the highest market demands, especially when it is grown for the French market. In most cases

the leaves are too small. This defect may be remedied to a considerable extent by selecting for seed those plants which have the largest leaves, and at the same time this will result in a material increase in the yield of the crop. When grown for plug wrappers, the size of the leaf is as important and worthy of as careful consideration on the part of the grower as when grown for cigar wrappers. In the manufacture of certain brands of plug tobacco the entire side of the leaf is used for one wrapper, which method is often preferable to using large leaves which have to be cut into two or more wrappers. Where this system is followed, leaves are demanded which are comparatively narrow and of sufficient length to cover the standard size of plug with the least possible waste.

A careful study of the size of wrapper desired by the manufacturer will give the grower a very definite idea of the most desirable size of leaf to produce, and by selecting plants having this style of leaf for seed the grower is enabled to produce uniformly the type of tobacco which will be best adapted to his market conditions.

In cigar-wrapper varieties of tobacco the size is of as much importance as the shape of the leaf. A short, wide leaf is always the kind most in demand, and has the advantage of being much less susceptible to injury in the curing barn. The manufacturers of certain brands of cigars prefer to cut only two wrappers from each leaf, and for this reason demand a very small, round leaf. Most manufacturers prefer a leaf sufficiently large for cutting two or more wrappers from each side, for the reason that nearly all classes of cigar-wrapper tobacco may be used more economically in this way. The size of Sumatra leaf most desired at present is about 16 inches long and sufficiently wide to admit of the most economical cutting. When leaves become very much larger than this there is danger of coarse venation, altho this can be very largely controlled by selecting for seed only those plants which produce leaves that have small, fine veins.

The question of venation is very intimately associated with both size and shape of leaf, and a certain correlation seems to exist between these characters. The writers have been able to produce types having leaves of desirable shape and size in which the venation is fine and in every way desirable. The experiments that have been conducted with this end in view prove beyond a doubt that these important characters may be successfully correlated and largely controlled by methods of selection and saving seed.

In curing tobacco in the barn the size of the leaf has been found to be an important factor. This has been clearly shown in the breeding experiments in the Connecticut Valley during damp curing seasons. One of the objects sought in Connecticut has been to secure a shorter

and rounder leaf than is now being produced in the Havana Seed and Broadleaf varieties. Numerous crosses have been made and hybrids produced with this end in view, and considerable progress has been made in securing a rounder leaf in the native varieties by careful seed selection. It has been invariably observed that these round-leaved varieties and strains have suffered much less injury from pole-sweat than the old standard varieties. This difference is attributed to the fact that in the case of the old long-leaf varieties the leaves after wilting hang down close around the stalk and adhere to one another, thus preventing the proper circulation of air when it is most needed for successful curing; while in the shorter, round-leaf types, the leaves stand out from the stalk, do not adhere closely together, and admit air freely to all the leaves on the plant, thus preventing in a large measure the injurious effects of pole-sweat or house-burn. The importance of the size of leaf from this standpoint can not be too strongly emphasized. The loss in the Connecticut Valley, as well as in many other sections of the country, due to pole-sweat often takes away the profit of the crop and is keenly felt by tobacco growers. The best crops are occasionally totally ruined by pole-sweat after they have been grown successfully and put into the barn in good shape. Therefore it can be plainly seen that the production of shorter, rounder leaved varieties in sections of the country where pole-sweat is disastrous will result in great profit to the tobacco growers and packers. Crops which have been badly injured in the barn are a source of endless trouble, and are very expensive to sort and pack successfully.

For cigar-filler purposes a comparatively small, short, and thick leaf is demanded. The small leaves are usually thicker and have better body and a very much better aroma and flavor than large, thin leaves. It has been definitely demonstrated from observations made by experimenters on the island of Cuba and from the observations of the writers made in certain filler districts of the United States that the best and most aromatic fillers are always obtained from plants producing comparatively small leaves. Plants which in a way seem to represent dwarf types or strains almost invariably produce leaves which have a much higher aromatic flavor than can be obtained from plants of the same variety producing larger and finer leaves.

In an attempt to improve the aroma of some of our domestic filler types thru breeding and selection the Department of Agriculture is endeavoring to produce new types of Cuban tobacco with very small leaves, with the belief that such types will have a superior aroma and will excel the filler grades which are now being grown in this country. These experiments have not advanced far enough to admit of any very definite conclusions, but they have indicated very clearly

that it is possible to produce better fillers by originating and perpetuating small-leaved varieties of tobacco. The yield from such types has been comparatively small, but by setting the plants closer together it is believed that there will be very little decrease in the yield to the acre in the production of small leaves uniformly thruout the crop.

The great variation in the size of leaf which is found in nearly all tobacco fields makes it possible to breed up and fix varieties which will produce uniformly the size of leaf most desired to meet special market demands. Plants producing small leaves are found growing along with those producing large leaves when all are, as far as we know, of exactly the same variety and grow under equal and uniform conditions. This variation is undoubtedly due to promiscuous accidental cross-pollination which has taken place in preceding generations. This variation in size as in shape of leaf also occurs much more strikingly on some individual plants than on others. Plants may be found in all tobacco fields with leaves of comparatively the same size and shape from the top to the bottom of the stalk, while in the majority of instances they are much smaller near the base and top than the middle of the stalk. By selecting seed plants that produce leaves which are uniformly of the desired size and shape from top to base of plant and by covering the flower heads with light paper bags, leaves very uniform in this respect may be grown the following year from seed saved in this manner.

Any tobacco grower will recognize immediately the advantages to be gained by producing types of tobacco in which the leaves on all of the plants are uniform in size and shape and where the leaves on the individual plants are likewise uniform in this respect from the top to the bottom of the plant. The yield of the crop will be materially increased, as will the value of the tobacco, while the cured product from such fields will be much more uniform in the packing house and the cost of handling proportionately reduced. The writers have already secured striking uniformity in some of the best strains of cigar and smoking tobaccos grown from seed which they have selected carefully and systematically for three years, and have found a considerable increase in the yield and value of the crop grown from such varieties.

A recognition of the importance of producing this uniformity is emphasized by the great number of demands made upon the writers for seed of these improved strains. It is easily within the power of tobacco growers to improve their present strains of tobacco in the shape and size of leaf, as well as in other characters, by selecting for seed the plants which are most nearly perfect in these respects and by saving the seed under bag according to the methods outlined

in this bulletin, in this way preventing intermixture with undesirable strains by accidental cross-pollination.

THE CONTROL OF THE NUMBER OF LEAVES ON INDIVIDUAL PLANTS.

The variation in the number of leaves borne by individual plants is just as marked as the variation in size and shape, but the size and shape are not always correlated with the number of leaves. In a general way it has been the observation of the writers that in cigar-wrapper tobaccos the plants which produce the best-shaped leaves usually produce more than the average number of leaves. The variation in the number of leaves on individual plants grown in the same field may be almost invariably attributed to the lack of systematic seed selection, to crossing, and to the use of a large proportion of light, weak seed in planting. The variation may be correlated with the height of the plants or the length of the internodes, or both. Different strains of the same variety are extremely variable in respect to the number of leaves produced, and until pure strains are developed no very great degree of uniformity in the number of leaves borne by individual plants in the crops may be expected. The production of strains true to type and uniform in the number of leaves, as well as other characters, is made possible by the careful selection of seed.

The control of the number of leaves is directly associated with the yield of the crop, and bears a very important relation to success in the handling and curing processes. The possibility of procuring a larger number of desirable leaves on each plant thru careful selection of seed is no longer doubtful, as is clearly borne out by experiments in tobacco breeding. An increase in the production of leaves borne by individual plants has been effected without any increase in the height of the plants and with no detriment to the quality of the tobacco. The reduction in the height of the plants is especially important in Sumatra tobacco grown under shade. It is difficult to prime or pick the top leaves from plants over 7 or 8 feet high, and it would not be advisable for the grower to produce plants which must be topt above that height. The most convenient height for a tobacco shade is about 9 feet. A tent higher than this would be difficult to build, and would be more liable to damage from severe windstorms; hence the necessity for keeping plants below this height by growing more leaves on each plant or by producing plants bearing shorter internodes. The Sumatra and Cuban varieties have a tall habit of growth, with long internodes, but respond readily to methods of breeding in the production of shorter stalks and shorter distances between the leaves.

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In all the varieties of tobacco which the writers have improved by seed selection and breeding the internodes are short and the number of leaves proportionally greater in the improved strains. In a careful count of the number of leaves to the plant in a good field of Sumatra tobacco the average was found to be between 19 and 20, while the records made in the breeding plats of strains of tobacco originally grown from the same seed as the general field where these leaves were counted show that the number of leaves was increased by two years' selection to an average of between 23 and 24. The breeding plats and the general field were grown under exactly the same conditions in order to eliminate any influences outside of the results of careful seed selection for the production of a greater number of leaves. The leaves produced on the plants giving an increased number were equal in size and more desirable in shape than those from stalks producing a smaller number.

The increase in yield due to the production of a greater number of leaves on individual plants and to shortening the internodes may be secured by systematic seed selection with no additional cost to the grower. Aside from the increase in yield, the quality of the leaf when there is a large number of leaves borne by the stalks is usually better than when the stalks produce but few leaves. This is particularly true in cigar and high-grade smoking tobaccos. None of the improved types of Sumatra tobacco have leaves sufficiently close together to cause any deterioration in the quality or texture of the leaf during the curing process. In the case of certain types of export and plug tobaccos and in some of the northern-grown cigar-tobacco varieties an increase in number of leaves is not desirable, for the reason that it is conducive to pole-sweat when the crop is being cured. It is further true in the case of these varieties that if the number of leaves is increased without shortening the internode, the plants will become too tall for expeditious handling. Therefore, it is necessary in certain varieties of tobacco to keep the leaves down to a certain definite number, with a desirable length of internode.

It is entirely possible for the grower to control largely the number of leaves by careful seed selection and in this way produce uniformly the plants which give the number desired. Care must always be taken in selecting for a large number of leaves not to increase the number at the expense of leaf uniformity. Only plants having leaves uniform in size and shape should be selected for seed purposes, and this selection must be kept up with unremittent persistency from year to year in order to hold constant the characters of improved strains of tobacco after they have been produced.

A large number of leaves to the plant is almost invariably closely correlated with a much lessened tendency to sucker and with de-

creased seed production. The plant food in such cases goes to the leaves, where it is most needed, and not into the production of suckers and of seed, which would be a loss to the grower. A large growth of leaf greatly retards the growth of suckers, and in some instances types have been produced which were comparatively suckerless—i. e., types which produced only very few and small suckers. These types are desirable not only from the standpoint of an increased leaf production, but the expense of suckering is in a large measure eliminated.

The habit of growth of the leaves, whether erect, or at right angles to the stalk, or drooping, greatly influences the number of "sand" or ground leaves obtained from the crop. When the leaves are drooping or pendent on the stalk the tips of a number of the lower ones come in contact with the ground and are often covered with sand or beaten and bruised by heavy rains, and are therefore partially or totally damaged. This loss of the lower leaves of the stalk can be very largely overcome by carefully selecting for seed those plants on which the leaves have an upright or erect habit of growth. This very important point in the habit of growth of the plant is often overlookt, but can be easily controlled by systematic selection. In view of the fact that the sand leaves are not nearly so valuable as those which have not been injured in this way, it is highly desirable that this habit of growth of the plant be kept constantly in mind when selecting plants for seed purposes.

The number of leaves on plants of a drooping habit of growth is sometimes greater than where the leaves grow erect or in an upright position, but where a large number of the lower leaves are badly damaged a larger number of the best grade of wrappers may be obtained from plants producing a somewhat smaller number of leaves, but all erect. Individual plants producing a large number of the desirable erect leaves may be found, however, and such plants should be saved for seed under bag in order to propagate the strain the following year.

THE PRODUCTION OF NONSUCKERING TYPES.

The number and size of suckers borne by individual tobacco plants are subject to considerable variation. In making selections of seed plants in many tobacco fields the writers have found plants bearing from 8 to 12 large suckers, and in the same fields other plants producing only one or two small suckers. In Plate V are shown two plants growing side by side in the field, at about the same stage of maturity, one of which bore five large suckers, while the neighboring plant bore only one small sucker. Instances of this kind are common in most tobacco fields. As can be seen in the illustration the nonsuckering plant has a larger number of more rounded leaves

than the suckering plant, which condition is usually true in all such cases.

The production of many large suckers is usually correlated with the development of few, heavy, dark, and usually narrow, pointed leaves. This condition is explained on the ground that the large sucker branches take from the plants the elements of plant food which otherwise would be utilized in the development of many broad, round leaves. The possibility of securing nonsuckering types of tobacco was suggested in the course of a series of experiments in the improvement of cigar-wrapper tobaccos. In the selection of seed plants great care was exercised to pick out those bearing the largest number of rounded leaves with fine veins. In the course of the study of the progeny of these plants it was observed that few suckers were produced by the most desirable types of plants. The continued observations on this subject have confirmed the conclusions that there is a correlation between the number, shape, and character of the leaves borne by individual plants and the number and size of suckers produced by these plants.

The number and size of the suckers produced by the plants in all tobaccos is an important practical problem from several standpoints. Owing to the dwarfing and otherwise injurious effect of the suckers it is necessary to remove them by breaking them off, or to "sucker" the plants, as the process is commonly called. There is great danger of breaking, tearing, or injuring the leaves during the suckering process, and this causes much loss in cigar-wrapper varieties, as the injured cigar-wrapper leaf is rendered practically worthless. A careless laborer frequently causes great loss to the grower during the process of suckering the plants. Owing to the fact that the suckers do not develop on all of the plants at the same time and consequently can not all be removed at once, it is necessary to go over the field several times during the season in order to remove all of them.

The cost of suckering is one of the important items of expense in the cultivation of tobacco. Therefore the production of nonsuckering types is an economic problem of great importance, not only by reason of the reduction in the cost of growing the crop, but from the fact that the nonsuckering types usually produce a larger yield of a more desirable quality of tobacco than the suckering types.

It has been found possible to produce uniform strains of different varieties of tobacco having but few and small suckers by saving the seed from nonsuckering plants under bag. As an illustration of the possibility of the growers producing such types the experience of one of the writers in the improvement of the Connecticut Broadleaf tobacco may be cited. In these experiments desirable plants were selected for seed in 1903, producing round leaves of fine, silky texture

and few suckers. The crops raised from this seed were found to produce but few suckers, the progeny of the different plants varying somewhat in this respect. From the strains producing the best type of leaves and bearing the least number and smallest size of suckers nonsuckering plants were again selected and the seed saved under bag in 1904. In the season of 1905 it was found that the progeny of these selections were almost free from large suckers. In one strain in particular only a few very small suckers, none of which grew more than 4 inches in length, were produced. The plants raised from ordinary seed of the same variety in the same field produced many large suckers, and as usual it was necessary to sucker the crop several times during the season. The remarkable difference in the suckering and nonsuckering habit has become so well fixt in this particular strain that a limited distribution of the seed was made for testing during the season of 1906.

It has been suggested that by saving seed from sucker branches strains of tobacco are developed which produce an increasingly large proportion of suckers; in other words, that sucker seed tends to produce suckering types of tobacco. In experiments with plants raised from seed saved from the central flower cluster the writers have observed little or no difference. As a rule, however, it has been found that the seed pods in the central flower cluster contain more large and heavy seed than the pods borne by the sucker branches, so that where seed is not carefully separated in order to secure only heavy seed for planting it is probably the best practise to save seed from pods borne by the central flower cluster of the seed head.

THE PRODUCTION OF EARLY VARIETIES.

Early maturing varieties of tobacco are of particular importance to northern tobacco-growing districts. Owing to the fact that frost kills the plants it is necessary for northern farmers to grow varieties which will mature between the time of the last frost in the spring and the first frost in the autumn. After the tobacco crops have been harvested and hung in the barns the curing processes are carried on most favorably during warm weather. The length of time required for the completion of the curing varies with the variety grown, the purpose for which the tobacco is to be used, and the weather. Under normal conditions, however, the natural curing period extends from four to eight weeks. It can readily be seen, therefore, that early-maturing varieties are likely to have more favorable conditions for curing than late varieties, as has proved to be the case in the experience of the tobacco growers in northern districts.

Another fact of importance in this regard is the likelihood of late-maturing varieties being injured in the field by autumnal storms. The earlier the crops can be harvested, the less is the probability of injury by severe rain, wind, or hail storms. In one district of the Connecticut Valley in the season of 1905 a severe hailstorm at about the usual time of harvest completely destroyed all except the early-maturing tobacco, which had been harvested and hung in the curing sheds. This experience is common to other northern tobacco regions and emphasizes the value of early-maturing varieties.

The uniformity in time of maturing of the individual plants in the fields is an important practical matter. In those districts where the tobacco crop is harvested by cutting off the plants near the ground all of the plants in a given section of the field must be cut off at one time. The immature plants can not be left to ripen and the early-maturing plants can not be harvested before the rest of the plants in the field. Overripe or underripe tobacco is likely to be of poor quality. In cigar-wrapper varieties the overripe leaves lack elasticity, gloss, and strength. The underripe leaves are likely to have uneven color and are susceptible to injury by various fungous and bacterial diseases. It is very important, therefore, that the individual plants in the field ripen uniformly, so that they can be harvested at one time without loss or injury.

The lack of uniformity in the maturity of leaves borne at the base, middle, and top of the plants is a cause of loss in value of the crop to the growers. As a rule the bottom or so-called "sand" leaves ripen first, the middle leaves next, and the top leaves last. In the varieties of cigar-wrapper or smoking tobaccos, especially where the entire plant is harvested at one time, the overripe sand leaves and the immature top leaves on such variable plants are inferior in value to the middle leaves. As stated, the color of these sand and top leaves is usually poor and undesirable, and there is also generally a corresponding inferiority in the texture and quality of these leaves. A careful study of the plants in tobacco fields at the time of the harvest has shown that individual plants bearing leaves that ripen uniformly from the bottom to the top of the plants can be found. In the experiments with the production of improved types of Connecticut Sumatra and Connecticut Cuban tobacco it was found that by selecting these uniformly ripening plants and saving the seed under bag uniform strains of these varieties could be produced.

The common practise of harvesting these varieties is to prime or pick off the lower ripe leaves first; then a few days later prime the middle leaves, and finally harvest the top leaves. In the case of the improved strains selected with the object of obtaining uniformly maturing plants practically all of the leaves can be primed at one

time. This improvement not only reduces the cost of harvest, but results in a more uniform crop of tobacco.

The differences in rate of growth of the individual plants in tobacco fields, resulting in varying times of ripening of the plants, is illustrated in Plate VI, figure 1. This degree of variability could be found in all the tobacco fields visited by the writers. In Plate VI, figure 2, are shown two rows of plants of the same variety treated exactly alike from the time of sowing the seed to harvest, one grown from the seed of the late and the other from the seed of the early plant shown in Plate VI, figure 1. The difference in time of ripening in this case was seven days; in other words, the early strain was ready for harvest one week before the late strain.

The experiments which have been conducted for the purpose of improving the different varieties of cigar wrapper and filler varieties and of smoking varieties of tobacco have demonstrated that it is possible for tobacco growers to improve the earliness of maturity of their varieties wherever such improvements are desirable. This improvement can be practically carried out by a careful study of the habits of growth of the plants in the field and the selection of the earliest and best plants for seed, saving the seed of these plants with precautions to prevent cross-fertilization. The production of earlier varieties requires several years of systematic selection and must be accompanied by a careful study of the quality and character of the product of the early strains. The practical limitation of earliness or the process of shortening the period of maturity depends on the effect of such change on the quality and yield of the early varieties.

Other things being equal, early-maturing varieties of tobacco are desirable, especially in northern sections, and can be produced by the growers thru the systematic selection of early seed plants. Uniformly maturing plants in a field and uniformly maturing leaves on the same plant are of great importance and can be produced by similar practical methods of seed selection.

THE IMPROVEMENT OF THE BURNING QUALITY.

The nature of the "burn" presents to the grower of cigar, cigarette, or pipe tobacco a most vital question, and, in the case of poor-burning tobaccos, an obstacle which is very difficult to overcome. All previous researches looking toward the solution of this problem have been confined to studies of the conditions of soil, fertility, cultivation, and fermentation, and their relation to the character of the burn of the tobacco, and thru the efforts of those who have carefully investigated these subjects improvements have been made in the burn of most of the varieties of tobacco. A thoro understanding of these phases of this question, however, does not wholly solve the

problem, nor does the improvement in methods of culture exhaust the possibilities in the production of uniformly good-burning tobacco. There are no cases on record of previous efforts having been made to improve by breeding and seed selection the combustibility of the varieties of tobacco. Believing it possible to produce better burning varieties in this way, the writers have endeavored in the course of their experiments during the past three years to produce strains of cigar-wrapper varieties which will burn more freely and uniformly than those which are grown at present.

Sufficient progress has been made to show very clearly that the variability in burn of tobacco produced by different plants is not altogether due to favorable or unfavorable conditions of soil, variations in kind or quantity of fertilizers, or to methods of fermentation, but that the individual plants themselves possess some innate character which bears a marked relation to the nature of the burn of the leaves. It is not definitely known whether this is due to the capacity of different plants to take up and assimilate the chemical constituents of plant food in different proportions or whether it is due to the difference in the physiological constitution of the leaves. To the practical tobacco grower it is of little interest to know the exact reason for this variability, but it is of most vital interest to him to know that it does occur, and that the good or poor burning quality of the plant is uniformly transmitted to its progeny, so that the nature of the burn can be largely controlled by seed selection. A difference in the soil or fertilizer, or in the treatment of the crop, always has a greater or less influence on the burn of tobacco, and must be taken into consideration; but in ordinary crops of tobacco, where all conditions are as nearly equal as possible, this marked variation in the burning quality of the individual plants still occurs.

The writers have found plants belonging to the same variety growing side by side under uniform field conditions which showed the widest variation in the nature of the burn. The product of one type of plant would burn freely and evenly, while that of another type had a very poor combustibility. This variation in burn can not be explained on the ground of any difference in soil or cultural treatment, but can only be understood by assuming that there are innate differences in the individual plants in this respect. The writers have proved beyond a doubt that this innate character does exist and is hereditary. Experimental plots of tobacco grown from the seed of the good and poor burning plants have shown that this character is extremely uniform in the progeny, provided other conditions are equal. Plate VII shows two rows of tobacco growing side by side, one of which produced a tobacco that burned very satisfactorily, while the product of the other was very deficient in com-

bustion under ordinary conditions. Taking this variability as a basis, it has been possible to produce by careful seed selection strains of tobacco possessing greatly improved burn without any change in the soil or in the method of handling the soil or the crop.

In the case of one variety of Sumatra tobacco to which the greatest objection was its poor burn, strains have been produced in the course of these experiments which burn in a perfectly satisfactory way without coaling or flaking. Even the top leaves in these particular strains have a free, even burn and good capacity for holding fire.

The production of improved burning strains requires more detailed experimental work than the improvement of shape, size, or number of leaves. No field character of the plant has been closely enough associated or correlated with the nature of the combustion of the cured leaves to make possible the selection of the best burning plants in the field. Consequently they can only be determined by actual burning tests of the tobacco after it has past thru the processes of curing and fermentation. For this reason the leaves of each seed plant must be carefully harvested separately and labeled in a manner to correspond with the label designating the seed saved from the same plant. It is always desirable that each priming of leaves be numbered or marked so that it may be identified after curing and fermentation. This enables the experimenter to make a test of the uniformity of the burn of the top, middle, and bottom leaves of each individual seed plant. There is considerable variability in the degree of uniformity of the burn of leaves borne on different parts of the plant, and therefore it is desirable to secure seed from plants which show a good burn in all the leaves, in order to produce a strain with uniformly good combustion. The leaves of all the seed plants should be cured and fermented under conditions as nearly normal as can be obtained in order to admit of a fair competitive test and to eliminate the possible influence of irregular conditions.

Where large numbers of samples are to be tested specially constructed apparatus is necessary to secure accurate results. A simple form of apparatus has been devised by Dr. W. W. Garner, of this office, for making these comparative tests. It consists of a series of glass tubes so arranged that each tube will smoke a cigar in very much the same manner as it is smoked by an individual, but with more regularity and uniformity. This apparatus is operated by means of an intermittent flow of water which subjects all the cigars to exactly uniform conditions. A carefully adjusted aspirator draws the proper intermittent current of air thru the cigars, and is so connected with the tubes that exactly the same strength of current is drawn thru each cigar. A paper has been prepared by Doctor Gar-

ner[a] which describes this apparatus and method of laboratory tests of the burn of tobacco in detail. By smoking several cigars at the same time by the use of this device it is possible to make very close and accurate observations on the rate and evenness of burn, color of ash, and other characteristics of the tobacco from different plants.

Cigars are prepared for this test from all the samples to be tested from the different plants and are allowed to dry out under natural but uniform conditions. The method employed by the writers in determining the comparative combustibility of the leaves from each seed plant is as follows:

One cigar is made wholly from the leaves of each plant, using the top leaves for filler, those next to the top for binder, and one side of a middle leaf for the wrapper. The other half of the wrapper leaf is reserved for a supplementary test, which will be described later. The object in making the entire cigar from the same plant, whether it is a filler or a wrapper type, is to eliminate the possible influence of any other tobacco upon that which is being tested. After the cigars have dried sufficiently, they are placed in the apparatus for smoking and all drafts excluded from the room to secure absolute uniformity of conditions. While the cigars are burning they are scored on the several points which go to make up a good or poor burn. The differences in character of burn of tobacco from the different plants when smoked under these uniform conditions is very surprising, and shows clearly the variability of the quality of burn in tobacco produced by different plants grown under uniform conditions.

The rate of burn is carefully determined, and the degree of uniformity or evenness noted. Some cigars will burn down on one side and go entirely out on the other, while others burn completely and evenly. Some will burn much more rapidly than others and with greater evenness. In many cases the wrapper puckers or swells just ahead of the fire, and often a shiny, metallic, black ring will appear just back of the burning tobacco. Sometimes both of these phenomena are present, and in this case the black ring, which indicates what is known as a metallic burn, appears between the fire on the cigar and the ring caused by the puckering or swelling of the leaf. These rings indicate a poor burn and are invariably associated with poor-burning tobacco and very frequently with an undesirable or bitter taste.

The comparative degree of coaling, i. e., a swelling of the wrapper at the burning point leaving a black ash, can be readily determined and noted in these tests. The character of the ash is also considered very important, and in case it flakes badly or is of a very dark, dull

[a] Bulletin No. 100, Part IV, Bureau of Plant Industry, U. S. Department of Agriculture.

color the seed from plants producing such tobacco is discarded. The seed from only those plants which produce tobacco that burns evenly, closely, and holds fire well, with no coaling and with a white, close, compact ash, is selected for further planting in the production of good burning types.

In the case of cigar-wrapper tobacco an additional test is made in which some standard filler and binder tobaccos are used and only the wrappers are taken from the plants to be tested. This gives an opportunity to observe the effects of other tobaccos on the burn of the wrapper and gives a test which may be compared to the testing of the wrapper in the ordinary way on cigars. A good, uniform grade of filler and binder is used in these tests. The wrappers from the best burning plants burn a little ahead of the filler, but hold fire well and burn evenly around the cigar.

These tests are further supplemented by another and more delicate one for bringing out the fine points of difference in the wrapper leaves from the individual seed plants without the possible influence of any other filler or binder, or of poor workmanship. Wrappers taken from the half leaf left in making the cigar test are placed on prepared forms, the shape and size of an average cigar, just as they would be placed on a cigar, and are allowed to dry on these forms. The forms are removed after the wrappers are thoroly dried, leaving the wrapper in the shape of a tube, just as it would be if it could be removed from the cigar in a dry condition. One end of this wrapper tube is placed over the end of a glass tube, upon which it fits closely. A current of air is then drawn thru the glass tube, entering at the end on which the wrapper was placed and of sufficient strength to give the best conditions for burning. The end of the wrapper is then lighted with a spreading flame, and accurate notes are taken on the length of time the tobacco holds fire and the character of the burn. The wrappers from the best burning leaves will burn up evenly, but where the combustion is at all deficient it is clearly brought out in this test. In many cases instead of burning evenly the fire will run in streaks about the leaf or will go out when it reaches a vein. Some of the leaves will scarcely burn at all under these conditions, while others will burn in a very satisfactory way. This final, delicate test is used more especially for cigar wrappers than for any other class of tobacco. In all cases a final test is made by smoking a cigar made from the tobacco under test.

Whether the grower uses the methods which we have described in testing the burn of his tobacco or not, it is comparatively easy for him to make a definite test of the combustibility of the leaves from all the plants which he selects for seed, and in this way gradually

breed up good burning types of tobacco in which the burn will be uniform thruout. This uniformity in type can only be secured by saving the seed of the plants producing the good-burning type of tobacco, these having been protected from cross-pollination according to the method described in this bulletin.

THE SELECTION OF SEED PLANTS.

The successful improvement of tobacco varieties by selection depends on the characters of the plants saved for seed production. Too much emphasis can not be given to the necessity for great care in the selection of seed plants. The history of the production of the valuable varieties of tobacco by seed selection is sufficient evidence of the importance of this subject. The running out or deterioration of the established varieties where careful seed selection has not been followed and the consequent deplorable financial condition of the growers of these inferior tobaccos is additional argument for the adoption of the most improved methods of saving seed by all growers. Inasmuch as any improvement in the yield or quality of tobacco means that much additional profit to the growers and manufacturers, attention to seed selection is a matter of direct financial importance as well as scientific interest.

The development of highly specialized means for manufacture and the increasing demand by the consumers for a variety of manufactured tobacco products are important reasons for the most careful study of seed selection as a means for producing tobacco adapted for the manufacture of special grades. In fact, a survey of the conditions of the tobacco growers in different sections shows that in those regions where a systematic attempt is made to produce a type of tobacco adapted to the specialized market requirements the prosperity of the tobacco growers is much greater than where no such attention is given to the improvement of the crop. It can be safely stated that the tobacco grower of the present day and of the future must either keep pace with the demands of the market or be forced out of business. Owing to the increased general prosperity and wealth of the United States, tobacco consumers are constantly demanding a higher grade of tobacco, a demand which, if taken advantage of by the producer, means greater profit and better prices for the specialized crops.

The common practise in selecting tobacco seed plants in many tobacco-growing regions is to save a group of a dozen plants, more or less, depending on the acreage of tobacco grown, in some convenient corner or section of the field where they will interfere least with the harvesting of the crop. A visit to any tobacco-growing region in the United States shortly after the crop is harvested will show these clumps of plants which have been left for seed. It is

usually the practise of the best growers to save portions of one or more rows producing the best plants, but frequently even this care is not given to this most important factor of tobacco growing. On the large tobacco plantations the writers have frequently observed a section of the field set apart for seed production. In some cases the poorest plants in such sections have been topt, while in others this practise has not been followed. This method of selecting seed plants is not as desirable as that employed in saving seed in most farm crops. It means that the growers do not take advantage of the variability of the individual tobacco plants in the field, and consequently lose the benefits to be derived from using the best plants as the parents for the next year's crop. After carefully studying the plants in hundreds of tobacco fields, the writers have found that the best plants do not grow in groups, but in different parts of the field, and can only be found by diligent search and careful observation of the crop, plant by plant, from the time the plants are set out in the field until they are topt. As soon as the benefits to be derived from seed selection and breeding have been demonstrated in tobacco-growing communities the growers are usually quick to take advantage of the improved methods of saving seed.

It has been frequently urged that change of seed is beneficial. In the light of recent investigations and observations on this subject this contention is believed to be incorrect in the case of tobacco. In other words, seed should be saved on the farm or field where the crop is to be grown. A change of seed is always experimental, and, as pointed out in the discussion of the introduction and acclimatization of new varieties, such change when necessary should be made only after carefully testing the seed for several years and securing by selection a strain which is adapted to the local soil and climatic conditions. In some tobacco-growing sections growers frequently buy their seed or obtain it from some other source than their own crop. While it may be true that this practise may be advisable in some cases—for example, when the seed is procured from tobacco-seed breeders having the same general soil and climatic conditions as the growers—this plan is not a good one to follow as a regular source of seed and is not practised by the most successful tobacco growers. The experience of the best growers and of scientific investigators of tobacco, as in the case of other farm crops, such as corn and cotton, goes to prove that the best policy is for every grower to save his own seed from the best plants in his crop. Instead of the varieties of tobacco running out by reason of having been grown under the same conditions continuously, it has been demonstrated that they are improved by the adoption of simple and practical methods for the selection of seed plants and the saving of seed.

In order that the grower or breeder may select seed plants intelligently it is necessary for him to form an ideal of the type of plant which it is desirable to grow. Without a clear conception of the type of plant desired any improvement by seed selection will be accidental. and as a rule the efforts in this direction will be unsuccessful. It is also necessary in forming the ideal to keep in mind the purpose for which the tobacco is produced in order to develop a type which will meet the demands of the market. For instance, in the growing of cigar-wrapper tobaccos a broad, round leaf, adapted for the cutting of the largest possible percentage of wrappers, is most desirable, so far as the shape of the leaf is concerned. The production of a high-yielding type must be governed in all cases by the effect of such change in the size and number of leaves upon the quality of the tobacco. The information necessary for the intelligent selection of desirable plants for seed can only be gained by a careful study of the plants, the cured and fermented product, and the market demands.

The plan of selection of seed plants followed by the writers is to examine with greater or less care, several days before topping, every plant in the field from which selections are to be made. As indicated before, it is always advisable to study the plants from the time they are set out, whenever this plan is practicable, with a view to picking out the best plants for seed. Such plants, when found, can be marked with a tag, string, or heavy rag, so that they can be readily identified when the final selection is made. Some characters, such as time of maturity, are more easily observed in the young plants than later; hence the importance of marking the plants showing the characters desired whenever they are found.

The size of at least three leaves in apparently desirable plants should be measured—one at the bottom, one near the middle, and another at the top of the plants. These measurements can easily be made with an ordinary yardstick, taking the length from the point of attachment of the leaf to the stalk to the tip and the width at the broadest point. The development of the top leaves by reason of further growth can be taken into consideration, tho in most tobaccos well-developed top leaves are correlated with early-maturing plants and always with uniformity of leaves on the same plant. The shape, size of veins, color, texture, and other characters of the leaves should be taken into consideration.

The number of leaves should be counted, also the number of suckers, and observations made, and, if possible, recorded of the uniformity of the shape, size, and other characters of the leaves in different portions of the plants, the presence of rust or other fungous or bacterial diseases, the height of the plants, and the space between the leaves, or length of internodes. The transmission of these charac-

ters from parent plants to progeny is shown in Plate VIII. A detailed estimate of the plants in the field in respect to these characters is valuable only as a guide to the selection of the best type of plants for a particular or a pedigree record, but must always be of secondary importance to the judgment of the grower as regards the general type of the plants and their adaptability for successful and profitable production.

In cigar-filler, smoking, and other varieties an intelligent selection can only be made by the study of the cured and fermented leaves. In this case it is necessary to save of plants that show in the field the general physical characteristics desired several times the number that will be necessary for seed. The leaves of these plants must be primed and kept separate, properly labeled, hung in the curing shed with the remainder of the crop so as to get normal curing conditions, and carried thru the processes of fermentation with the bulk of the crop. After the fermentation or sweating process has been completed, the samples from the individual plants can be tested, the seed from the poor plants discarded, and the seed from the best plants saved for planting. A description of the apparatus which has been devised in the Office of Plant Breeding Investigations for testing the burn or combustibility of cigar wrappers and for assisting in the comparison of the quality of cigar-filler and smoking tobaccos has been published, as previously stated. In the study of the samples from the individual seed plants it is absolutely necessary that they all be brought under uniform conditions of moisture, heat, and other conditions affecting the character of the leaves before the tests are made. Final tests must always be confirmed by the use of the tobacco in cigars, pipes, or by other means of consumption for which the tobacco is adapted.

RECORDS OF BREEDING WORK MADE IN THE FIELD.

The form of record blank used in the breeding work of the writers, together with the directions for note taking and definition of terms, is given here for the benefit of those who may wish to carry on systematic breeding work and keep a pedigree record of the parent plants and their progeny. This plan of record keeping is being constantly revised as the knowledge on the subject increases, but up to the present time the plan described has been found to be very useful and valuable, covering the most important characters and points necessary for an adequate record. The plants finally selected for seed are usually given a number for identification, this number being written on a small, strong tag attached to the top of the plant below the paper bag with a short piece of flexible wire.

The following form for note taking in the field is printed on a large shipping tag:

Tobacco } No.....
U. S. P. B. }
Date .....
Type .....
Leaves:
Number ..... Length .....
Width ..... Thickness .....
Shape ..... Color .....
Uniformity ..... Rust .....
Spots ..... Gum .....
Maturity ..... Position .....
Venation .....
Stem:
Height ..... Circumference .....
Length of internodes .....
Suckers:
Number ..... Size .....
Position .....
Seed:
Number of pods .....
Date of picking .....
Harvest:
1st 2d 3d

The directions for note taking for use in making field notes adopted by the Office of Plant Breeding Investigations of the United States Department of Agriculture are as follows:

In order to secure uniformity in nomenclature and note taking and promote uniform methods of classification in the tobacco-breeding experiments the following system has been adopted and should be closely adhered to by those conducting these experiments and applied to all records made in the course of these investigations:

NOMENCLATURE.—The word *variety* should be used to designate distinct, well-recognized, and established kinds of tobacco; as, for example, Sumatra, Connecticut Havana, White Burley, and Zimmer Spanish.

The word *strain* should be used to designate a slight local modification of a variety in which some intrinsic quality has been bred, such as tendency to produce a heavier yield, improved shape of leaf, or better adaptability to local conditions, as, for example, Cooley's Connecticut Havana, Connecticut Sumatra, or Jones's Zimmer Spanish.

The word *type* should be applied to new varieties which are selected for experimental purposes and have not come into commercial use.

TYPE NUMBERS.—In the fields where selections are made several distinct types may be found, and a number of seed plants should be selected for experimental purposes in each type. A number should also be given each type, and in all records of experiments with this type it should be referred to under this number. When a new type is found the list of existing type numbers should be consulted, so that no two types may be given the same number. For example: *Variety*, Sumatra; *strain*, Connecticut Sumatra; *type*, *1* (Crumple). Wherever it may be desirable the type may be further

identified by a distinctive name, as for example, in the case of the Connecticut Sumatra strain, *type, 2* (Green leaf); *type, 4* (Broad leaf).

SELECTION NUMBERS.—The individual plants selected for propagation should be given numbers which will serve to identify them, as well as the type and the generation to which they belong. Each plant is represented by a combination of numbers, the first one representing the series and usually corresponding to the type in which the plant belongs. Each succeeding number represents the individual parent plants in that generation, the last being the number of the individual selection in the last generation. For example, in the experiments with the improvement of Connecticut Sumatra tobacco in the second generation of selections the following numbers have been used: 1–5–6. The first number (1) refers to the series, and, in this case, to type 1 in the Connecticut Sumatra strain; the second number (5) refers to the number of the seed plant selected and used for planting the second generation; the last number (6) refers to the seed plant saved for planting the third generation selected from the crop raised from plant No. 1–5; while 2–3–8 refer to a selection of the green leaf Connecticut Sumatra type, plant No. 3 of the first generation, and plant No. 8 of the second generation selected from crop raised from No. 2–3.

HYBRID NUMBERS.—The general plan of assigning numbers to tobacco hybrids is similar to the system followed in the selections except in the case of the type number, which consists of a figure and a letter. The letter is added to the figure in order to distinguish the hybrids from the selections and may be used to identify the individual hybrids of similar parentage. A different type number should be given to each series of hybrids, and a different letter to each hybrid within the series, as, for example, 41a, 41b, and 41c refer to individual hybrids between Connecticut Havana and Connecticut Sumatra; 42a to hybrids between Connecticut Havana and Connecticut Cuban, and 43a to hybrids between Connecticut Broadleaf and Connecticut Cuban, respectively. The hybrid numbers should not be duplicates of the selection numbers.

ASSIGNMENT OF NUMBERS.—In order to prevent confusion arising from using the same numbers in different sections, it is proposed to assign certain numbers to each natural center of breeding experiments. These numbers should be consulted before new numbers are given to types or hybrids. The numbers from 1 to 100, inclusive, are assigned to the Connecticut Valley experiments; 101 to 200, inclusive, to the Florida experiments, and 201 to 300, inclusive, to the Maryland experiments.

The names of the established varieties of cigar-wrapper tobaccos grown in the Connecticut Valley are (1) Connecticut Havana; (2) Connecticut Broadleaf; and the varieties introduced in an experimental way which are grown to a limited extent under cloth shade are (1) Sumatra and (2) Cuban. A number of distinct strains of Sumatra and Cuban varieties grown from imported seed have been produced and are recognized as modified types of the Sumatra and Cuban tobaccos, so that in order to distinguish these types from the imported varieties they should be known as Connecticut Sumatra and Connecticut Cuban tobaccos. The types which have been selected for experimental purposes are as follows: Connecticut Sumatra type: 1, Crumple; 2, Greenleaf; 3, Sumatra; 4, Broadleaf; 5, Belgian; 6, Abnormal; 7, Smoothleaf; 8, Freak; 9, Mosaic; 10, Mongrel; 25, Holcomb Hollow; 27, Resistant; 28, Diseased. Connecticut Cuban type: 11, Cuban; 12, Dark Green; 13, Havana; 14, Freak. Cuban: 20, Imported Cuban. Connecticut Havana: 36, Cooley. Connecticut Broadleaf: 50, Brewer; 55, Favorite.

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The principal variety of tobacco grown in Florida for cigar-wrapper purposes has been developed from imported Sumatra seed and is commonly known as Florida Sumatra tobacco. The Florida Sumatra types which have been selected for experimental purposes are: 101, Lott; 102, Attapulgus; 103, Ovalleaf; 104, Greenleaf; 105, Shortstem; 106, Prolific; 107, Spiralbud; 108, Corry; 109, Fain; 110, Bell; 111, Gregory.

The variety of tobacco grown in Maryland for smoking purposes is commonly known as Maryland Smoking. The types which have been selected for experimental purposes in this variety are: 201, Sasser; 202, Satin; 203, Thickset; 204, Narrowleaf; 205, Red Clay; 206, Hill; 207, Holland; 208, Drury; 209, Long Red; 210, Wilson.

MEASUREMENTS OF STEMS.—The height of the stem of seed plants should be measured from the surface of the ground near the base of the plant to the last 12-inch leaf at the top which would be left after topping. The height of stem-topt plants should be measured to the leaf that will be highest after topping, so that in all cases the length of internodes may be determined by dividing the height of the stem by the number of leaves borne by that plant. The measurements should be made at the time of the first priming or just before cutting.

The circumference of the stem should be measured half way between the point of attachment of the middle leaf and the one next below, just before harvest.

MEASUREMENTS OF LEAVES.—The third leaf from the bottom (1), the middle leaf (2), and the third leaf (3) from the top should be used for determining the size of leaves. The length should be measured from the point of attachment to the tip of the leaf. The width should be measured at about the middle of the leaf at its widest point.

The number of leaves counted for record should include all except those top leaves under 12 inches in length which would be cut off in topping.

DESCRIPTIONS OF LEAVES.—Definitions of the terms used in the description of leaves are given below:

Shape:

Linear. Narrow; several times longer than broad.
Lanceolate. Tapering; several times longer than wide.
Oblong. Nearly twice as long as broad.
Elliptical. Oblong, with flowing lines.
Oval. Broadly elliptical.
Ovate. Like section of a hen's egg.
Cordate. Heart-shaped.
Obovate. Larger at tip than at base.

Uniformity:

Very good. All leaves alike from top to bottom of plant.
Good. The midddle leaves alike.
Medium. Irregularity not marked.
Poor. Irregularity marked.
Very poor. Very undesirable irregularity.

Position:

Erect. Makes sharp angles with stem.
Partly erect. Between erect and horizontal.
Horizontal. At right angles with stem.
Drooping. Tops of leaves drooping.
Pendent. Hanging downward.

Venation:

Coarse. Large midrib and veins; veins spreading over entire leaf into margins.

Medium. Large veins in central portion of leaf.

Fine. Small midrib and veins; veins not prominent in the margin of the leaf.

Rust:

None. Absence of rust.

Slight. A few spots on few leaves.

Injured. Parts of the leaves destroyed.

Destroyed. Most of the leaves rusted.

Leaf spots:

None. No spots present.

Incomplete. Part of the leaves evenly spotted.

Complete. All of the leaves evenly spotted.

Irregular. Part of the leaves irregularly spotted.

Amount of gum:

Slight. Very little gum present.

Medium. Deficient.

Normal. The desirable quantity.

Excessive. More than desirable.

Maturity:

Very early. About two weeks earlier than medium.

Early. About one week earlier than medium.

Medium. Usual time of maturity.

Late. About one week later than medium.

Very late. About two weeks later than medium.

Thickness:

Thick. Very coarse and heavy.

Medium. Usual thickness.

Thin. Light and thin.

Very thin. Very thin texture.

Color in field:

Very light. Pale yellowish green.

Light. Pale green.

Medium. Green.

Deep. Concentrated green.

Dark. Dark green.

Very dark. Very dark green.

Yellow. Yellow green.

Very yellow. Deep yellow green.

Color in warehouse:

Very light. Very light brown.

Light. Light brown.

Medium. Most desirable brown.

Dark. Dark brown.

Very dark. Very dark brown.

Elasticity:

Strong. Leaf stretches without tearing.

Medium. Between strong and weak.

Weak. Does not stretch and tears easily.

DATE OF GERMINATION, ETC.—In making notes on the date of germination and date of coming up the following outline may be used:

Date of germination:

Very early. Most vigorous and early.

Early. Vigorous and large percentage sprouted.

Medium. Medium early.

Late. Few sprouted.

Very late. Very few sprouted.

Date of coming up:

Very late.

Late.

Early.

Very early.

DATE WHEN CURED, ETC.—The date in column headed *Cured* (in the record form for field notes) is the time of taking down the leaves in the sheds. The date in column headed *Bulked* is the time the tobacco is put in bulk and fermendation begun. The date in the column headed *Fermented* indicates the time that the tobacco has finished fermentation in bulk and is ready for sizing and assorting. *Yield* is the weight of each grade as assorted for trade conditions.

PERMANENT RECORDS OF BREEDING WORK.

A convenient way for making a permanent record of the individual notes on the parent plants and their progeny is shown in the following form, which is printed for the Office of Plant Breeding Investigations on sheets kept in a "loose ledger" cover adapted for this purpose:

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Tobacco selection.

Individual sheet.

P. B. Form 25.

Tobacco Selection No. .....

Parent variety ..... U. S. P. B. No. .....

Locality ..... Field ..... Type ..... Date ..... Experimenter .....

Individual notes:

Seed.						Leaves.														
Date sown.	Date of germination.	Date sown in seed bed.	Date of coming up.	Uniformity of young plants.	Date transplanted.	Number.	Length.	Width.	Thickness.	Shape.	Uniformity.	Position.	Rust.	Spots.	Amt. of gum.	Maturity.	Color. F.	Color. W.	Elasticity.	Venation.
							1													
							2													
							3													

Stem.			Suckers.		Type.	Seed pickings.			Harvest.			Cured.	Bulked	Fermented.		Yield.			Total score.
Height.	Circumference.	Length of internode.	Number.	Size.					1	2	3					1	2	3	
																4	5	6	
																7	8	9	
																10	11	12	

Progeny notes:

Seed.							Leaves.													
Date sown.	Date of germination.	Per cent of germination.	Date sown in seed bed.	Date of coming up.	Uniformity of young plants.	Date transplanted.	Number.	Length.	Width.	Thickness.	Venation.	Shape.	Uniformity.	Position.	Rust.	Spots.	Amt. of gum.	Maturity.	Color. F.	Color. W.	Elasticity.
								1*	1												
								2	2												
								3	3												

Stems.			Suckers.						Maturity.	Harvest.			Cured.	Bulked.	Fermented.	Yield.			Total score.
Height.	Circumference.	Length of internode.	Number.	Size.						1	2	3				1	2	3	
																4	5	6	
																7	8	9	
																10	11	12	

In the breeding work conducted by the writers a portion of the seed from the plants saved for seed is sown in small sections in the seed beds and the plants are subsequently transplanted to separate rows in the field. From the rows of plants producing the best type and quality of tobacco further selections of seed plants are made. In this way the productive capacity of the individual seed plants can be tested and a record of their performance made by the breeder. Usually 100 plants are grown from the seed of each seed plant in the individual rows in the test plats.

The sections of the seed beds necessary for producing this number of plants at one time for transplanting are usually 3 by 3 feet in size, boards one-half inch in thickness and 6 inches in width being used for making the partitions. These boards are usually sunk in the beds about 2 inches to prevent mixture of seed between the different sections. Necessarily the quantity of seed required to sow these sections is very small, about 1 gram being used for this purpose, which should be taken from the general seed product of the individual plant. The seedlings from these sections can be transplanted by hand, care being taken not to injure the roots, and sufficient water supplied to start the plants under favorable conditions. This plan of testing the individual seed plants may not be practicable for the grower of a small crop, but can be used to advantage by tobacco breeders.

After the seed plants have been selected in the field the flowers should be protected from cross-fertilization and the seed saved in accordance with the directions given under the head of methods of saving seed.

METHODS OF SAVING SEED.

The absolute necessity of saving seed free from cross-fertilization was recognized by the writers in the beginning of the tobacco-breeding experiments. The readiness with which tobacco flowers are cross-pollinated has been shown in a previous section, giving a description of the flower, and has been emphasized all thru this bulletin. The securing of pure, unmixt seed is necessarily of the first importance in developing improved strains of tobacco which are sufficiently uniform to meet the requirements of the manufacturers. After trying various methods of keeping the seed pure by covering the flower head of the plant it was found that the most practicable and efficient way to protect the flowers from cross-pollination was by the use of a light, strong manila paper bag, which serves to keep out all agents whereby pollen may be transferred from plant to plant and from flower to flower, and at the same time does not interfere with the proper development of the flower head and the seed. This method impresses

all growers at first as being impracticable, but it has been found by the writers and by many growers who have adopted it to be thoroly practicable and in every way effective. Nearly all the growers in the Connecticut Valley, where the work was first begun, are saving their seed in accordance with this method, which is sufficient evidence of its adaptability to practical farming conditions. The form of bag used must not be thick or heavy enough to affect the natural transpiration and growth of the plants. The kind which has been adopted for general use is the lightest grade of manila bag that can be procured at the grocery or country stores. There is greater liability of the seed being injured under southern or tropical conditions by using a bag which is too heavy than there is in the North. In order to prevent any possibility of injury from this cause, the writers have adopted the method of puncturing the bag with a large number of very fine holes, which will admit air and at the same time are not large enough to allow insects to pass through and carry the pollen from plant to plant.

FIG. 6.—Tobacco seed plant at proper stage of maturity for the application of a paper bag. The bag should be placed over the seed head just before the first flowers open. The top leaves and sucker branches should be removed before arranging the bag, in order that nothing may interfere with the development of the seed head.

The bags may be punctured by using a sewing machine and arranging the bags as in sewing ordinary cloth. The sewing-machine needle of course must not be threaded for this purpose. For the average tobacco plant the paper bag of 12-pound size has been found to be the most satisfactory. When the plants to be bagged are of a small variety, the 10-pound bag may be large enough, but it will not allow sufficient room for the proper development of the seed head on a tobacco plant of average size.

The proper time for bagging is just before the first flowers open and are ready for pollination. At this time the stem of the flower head is sufficiently strong to support the weight of an ordinary paper bag without injuring the plant in any way. When the bags are applied earlier than this, the operation is more difficult and the tender top of the plant is liable to be broken off or bent by the weight of the bag. When the growing plant has reached the proper stage for bagging, all branches just below those which form the main flower head

and all small leaves should be carefully removed. The accompanying illustration, figure 6, shows the earliest flowers just ready to open, which indicates the right stage of development for bagging. After the flower head has been carefully prepared, as indicated, the bag should be inverted, placed over the flower head, the mouth gathered closely around the stem just below the flower branches and tied loosely enough to allow sufficient room for further growth, as shown in figure 7. At this stage of the plant's development the flowers bloom rapidly, and a corresponding rapidity of growth takes place in the flower head. This condition makes it necessary to visit the bagged plants in the course of five or six days in order to take the bags off and remove all superfluous growth in the nature of small leaves, so as to give as much room as possible for the development of the flowers. The bag must be replaced immediately, before insects have an opportunity to visit the flowers and transfer pollen. This process should be repeated two or three times during the season and the bag elevated each time in order to allow for the rapid growth of the stem.

FIG. 7.—Tobacco seed plant showing arrangement of a paper bag for the protection of the flowers from cross-fertilization. At this stage of development a tobacco plant increases in length very rapidly; consequently, the bag should be tied loosely so that it can be easily pushed up the stalk.

After a sufficient number of pods have set seed to produce the normal quantity of seed, the bag may be removed to prevent any possibility of mold during continued periods of rainy weather. When this is done all late buds and flowers must be broken off, leaving only the pods which have been fertilized to produce seed. It is also desirable to remove all seed pods which are poorly developed, in order to eliminate some of the seed which is likely to be light and undesirable.

When all the pods are mature the plants are cut in the ordinary way and hung to dry in a barn or other place having a free circulation of air. In order to catch the seed of pods which open during the process of drying, it is customary to put new bags over the seed heads at the time the plants are cut. Thoroly dry seed may be shelled and stored in glass vials or bottles with perfect safety, and can be kept almost indefinitely in this way. The fully matured

and dry tobacco seed will retain its vitality when kept dry for ten years, or, as has been observed in several cases, a much longer time.

The seeds saved in accordance with the methods here outlined are larger, heavier, and of higher vitality than those saved in the ordinary way. Self-fertilized seeds are free from the introduction of hereditary tendencies from surrounding plants, and the characters of a single plant are transmitted to the progeny with almost as great uniformity as in the case of vegetative reproduction or propagation from cuttings.

This method of saving seed requires very little more time than the old method, and at the same time gives the grower an opportunity to study the types of tobacco in the field by coming in closer contact with the seed plants themselves. He will of necessity make closer observations as to the points of perfection or imperfection in individual plants, and by protecting the flowers from cross-pollination it is entirely possible for him to produce a pure and uniform strain of tobacco after selection for two or three years, to improve his tobacco in every way, and to weed out the undesirable and unprofitable types which occur so frequently in the general tobacco field.

SEED SEPARATION.

The special value of large, heavy seed in the production of general farm crops has long been established. Careful farmers and seed growers have used various methods for selecting this grade of seed for planting. Experiments with light and heavy seed in this and other countries have demonstrated clearly and conclusively that larger yields are obtained from heavy, plump grains than from small, light seed. Live-stock breeders do not breed from weak or poorly developed parents, and it is just as important that plants be bred from heavy seed with strong parentage as to use the best animals in the production of improved breeds of live stock.

The writers have found this principle to be strikingly emphasized in the production of tobacco from different grades of seed. The plants from large, heavy seed not only grow more vigorously, but have greater resistance to certain bacterial and fungous diseases and show greater uniformity in the field and warehouse than plants produced from inferior seed. Thus it can be seen that the specific gravity of individual seeds has a very important bearing on some of the main factors in the production of profitable crops of tobacco. The reason for this is very evident when we consider the fact that the heavy seeds contain a larger supply of food for the development of young plants than the light seeds. It is not always true that the heavy seeds germinate first, or that the plantlets from such seeds make the most rapid growth in early stages of development, but they always

make a healthier, more strudy, and stronger growth, and produce much better plants in the end. The comparative size, production. earliness, and other characters of plants raised from light and heavy seed are shown in Plate IX, figure 1. It frequently happens that the light seed are the first to germinate, and in some cases the young plants from the light seed are first to reach the proper stage for transplanting. However, after they are about half grown they show freaky tendencies and are very susceptible to various diseases, are unstable, and of little value to the tobacco grower. They sometimes bloom earlier and mature before the average well-developed tobacco plants in the field, but are deficient in yield and other important qualities. Such plants are, of course, undesirable from every standpoint and should be eliminated before being transplanted to the field, so as to give place to vigorous plants grown from heavy seed.

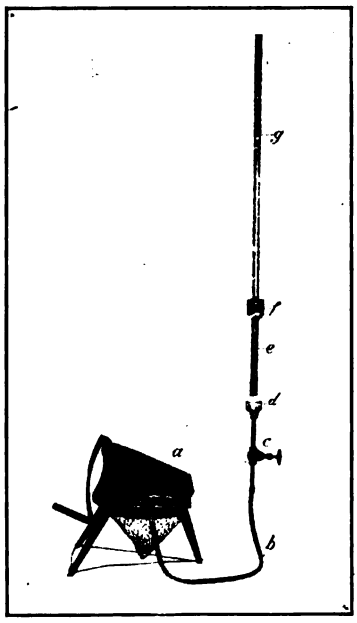

FIG. 8.—Tobacco seed separator. This apparatus separates the light, immature, and poor seed from the heavy seed, and can be so regulated as to furnish any degree of fineness of separation desired. It is now being used extensively by tobacco growers.

It is almost impossible to select and discard in the seed bed the weak plants produced from light seed, so that it must be done, if at all, before the seed is sown. Doctor Trabut, in his experiments with tobacco, sought to make a separation of tobacco seed according to different degrees of specific gravity by throwing the seed upon water and discarding those that continued to float after a certain length of time. This process effects a partial separation, but it is incomplete. The extremely small size of tobacco seed makes this method rather impracticable, for the reason that minute air bubbles will adhere to the seed for a considerable time and hold many of the heavy seed on the surface, while some of the lighter ones will lose the air bubbles first and sink to the bottom with the heavy seed. Notwithstanding the incompleteness of this method, Doctor Trabut found a great difference in the growth and productiveness of the seed which sank to the bottom of the vessel first, and he brought to light new and vital facts regarding the importance of using heavy seed.

In order to secure a more complete separation of the light from the heavy grade of seed, the writers have devised a simple and practical

wind-blast apparatus, shown in figure 8, for separating tobacco seed into heavy and light grades. This apparatus has already come into general use by tobacco growers in the United States and other countries. It was described by Mr. A. D. Shamel in the Yearbook of the Department of Agriculture for 1904. The seed separator here illustrated is a slight improvement over the original apparatus as described by Mr. Shamel.

The improved apparatus consists of a foot bellows (*a*), connected with a globe valve (*c*) by means of a rubber tube (*b*). The valve (*c*) is connected directly with the seed receptacle (*e*). The seed receptacle consists of a 1-inch glass tube (*e*) about 14 inches in length, cemented in the reducer (*d*) with plater of Paris. At the extreme bottom of the glass tube *e* and just above the top of the valve (*c*) a fine wire gauze is fastened. The object of this gauze is to prevent the seed from falling into the valve from the receptacle, and therefore it is necessary to use a wire gauze with very small mesh. An ordinary gas pipe coupling (*f*), about 3 inches in length and slightly larger than the tube *e*, is firmly cemented to the top of the tube to serve as a support for the tube *g*. The tube *g* is of glass the size of tube *e* and about 6 feet in length. The apparatus can be supported by a convenient frame, which may be fastened to the wall or set up wherever desired.

The bellows and tubing for this apparatus may be procured from any chemical supply house, and the remaining parts from hardware stores. They can be easily put together and the apparatus set up in the proper manner by anyone who wishes to use it. A complete device of this nature should not cost more than $5, a very small sum compared with the benefits to be derived from getting rid of the light and undesirable seed. In the successful operation of this apparatus the following method should be employed: Pour about 1 ounce of the tobacco seed to be separated into the seed receptacle, and by means of the foot bellows pass a current of air of sufficient strength thru the entire apparatus. The strength of the current of air may be regulated by the globe valve so as to blow out the desired proportion of the light seed. The light seed is blown out thru the top of the tube and the heavier seed falls back into the seed receptacle. The degree of separation may be controlled accurately by means of the valve, the length of the tube, and the working of the foot bellows. A much more complete separation may be made by the use of a long tube than where a short one is used.

This simple apparatus serves to completely eliminate the evil results associated with the use of light and inferior seed. It is thoroly practical in every way, and delicate enough in its operation to separate the smallest kinds of seeds according to their individual speci-

fic gravity. One apparatus is sufficient to separate seed for an entire community, a plan which is being followed in some cases. A pound of seed may be separated in less than half an hour. Thus it is seen that the apparatus and cost of operating are very small and not sufficient to prevent any tobacco grower from eliminating all light and poorly developed seed, in this way not only increasing the yield, but also improving the uniformity and quality of his crop.

DISEASE RESISTANCE.

In practically all fields producing diseased tobacco plants where the writers have made observations some degree of immunity has been noticed in individual plants which have been found growing among badly diseased plants on infected soil. These cases of immunity could not be explained on the ground of any differences in treatment, but their resistance to disease was evidently inherent in the individual plants. The same conditions have been found by other investigators and workers in other farm crops, and from these resistant individuals many immune strains have been developed. Among the most notable are the variety of wilt-resistant cotton, improved by Mr. W. A. Orton and Mr. Rivers, and the Iron cowpea, which is resistant to root-knot caused by nematodes, improved by Dr. H. J. Webber and Mr. W. A. Orton. The transmission of this immunity found in individual plants has made it possible to develop immune strains, and in that way to produce thoroly healthy crops on disease-infected soils.

In most cases where immune plants occur, if seed is saved from a large number of such plants some of them will be found to transmit their resistance to the progeny uniformly and thus give rise to the easiest known method for the control of certain plant diseases.

In the case of tobacco, the seed of the immune plants must be saved, with precautions to avoid cross-pollination, to insure the best results. In the season of 1903 the writers made selections of plants in several tobacco fields in the Connecticut Valley which showed immunity to the tobacco wilt. These plants stood out very plainly and strikingly in the diseased sections of the field, making a normal growth, and were apparently not affected by the wilt in any way, while plants growing all around them were so badly diseased that they produced no tobacco, and many of them died before maturing seed. Seed was also saved from some of the diseased plants that reached maturity. Two rows were planted the following year on the infected soil, one from seed of a resistant plant and the other from seed of an immune plant, with the results shown in Plate IX, figure 2. In this instance, by reason of the foregoing and other observations, it was found that complete resistance to the wilt was obtained by one year's selection.

A wilt in tobacco occurs in North Carolina which is evidently a parallel case with the one found in Connecticut, and in all probability could be controlled in the same way.

One of the most serious diseases affecting tobacco at present is the root-knot caused by nematode worms. Tobacco seems to be particularly susceptible to the attacks of nematodes, and many crops are more or less seriously affected by this enemy. There is no known remedy for this pest that is applicable in a practical way to field conditions. Soil-sterilization methods are used successfully in plant beds or in greenhouses, but such treatment is rather too expensive to be used on large fields. The most practicable method for the control of this disease seems to be in the way of securing immune strains of tobacco by seed selection and breeding. The writers have selected a large number of individual plants that showed immunity in the field, and the seed of these selections will serve as a basis for experiments in the production of nematode-resistant types. The complete success of other workers in obtaining resistance to nematodes in varieties of sugar beets and cowpeas is good evidence that similar results may be obtained in their efforts to obtain resistance to this enemy in tobacco. The Iron cowpea shows strong resistance to the nematode when planted on badly infected tobacco fields, and for this reason can be highly recommended to tobacco growers for use in this connection.

The mosaic disease causes very serious injury in tobacco fields in many parts of this country. The writers believe, from indications observed during the past two years, that it will be possible to develop strong, vigorous strains of tobacco which will be largely resistant to this disease. In the case of some Maryland selections, resistance to the mosaic disease seems to have been transmitted in a large degree to the progeny of certain vigorous strains. In two plats grown side by side under uniform conditions, one from seed of a parent plant affected with mosaic disease, the other from a perfectly healthy one, the following results were obtained: Plat 1, grown from the seed of the mosaic plant, showed 80 per cent of diseased plants in the field; plat 2, grown from the seed of a perfectly healthy plant, showed less than 20 per cent of diseased plants. It may be impossible to entirely eradicate this disease by the production of immune varieties, owing to the peculiar nature of the malady, but these figures, which have been duplicated many times, show very conclusively that by the development of stronger and hardier types of tobacco, especially where heavy seed is used for sowing, it will be possible to gradually reduce the percentage of mosaic plants in ordinary tobacco fields.

There are numerous tobacco diseases which the writers believe may be largely eradicated by producing immune strains. It is the intention of the Office of Plant Breeding Investigations to take up work with as many of these diseases as seems practicable and endeavor by selection to produce resistant types wherever it is possible to do so.

FIG. 9.—Typical plant of Uncle Sam Sumatra tobacco, originated by the Department of Agriculture in the Connecticut Valley from Florida-grown seed and now being extensively grown for cigar-wrapper production. The shape, size, venation, stretch, color, gloss, and other characters are specially well suited for cigar wrappers. This variety yields a large number of the best grades of wrappers, and is very uniform in all characters. It is a vigorous-growing plant, of early maturity and small seed production.

A NEW VARIETY PRODUCED BY SEED SELECTION.

UNCLE SAM SUMATRA.

The original plants from which the variety of tobacco known as Uncle Sam Sumatra has been produced by seed selection were grown under shade on the plantation of the Connecticut Tobacco Corporation, near Tariffville, Conn. The first selections were made in the season of 1903 on this plantation in a field the plants of which were grown from seed originally brought from Florida. The Florida seed was produced by plants which were grown from seed originally imported from the island of Sumatra. In a careful study of the Connecticut-grown Sumatra crops in 1903 a number of distinct types were discovered, some of which were evidently very undesirable, while others were apparently desirable. A striking illustration of two of these types is shown in Plate VIII. The seeds of typical plants of these types were saved under bag and tested in 1904 in an experimental field of 4 acres on the Indian Head Plantations, at Granby, Conn. Further tests of the Uncle Sam variety in the season of 1905 in the Indian Head Plantation experimental field and in other fields in the Connecticut Valley and of plants of this variety grown in Florida from Connecticut-grown seed have demonstrated the value of this variety for growing under shade for the production of cigar wrappers. The original plants of the Uncle Sam variety showed striking variations from the generally accepted type of Sumatra tobacco, but were believed to more nearly approach the ideal of a desirable cigar-

wrapper variety than other types. In the experimental stages the plants belonging to this type were classed as type 3 and called Sumatra to distinguish it from the other types. As soon as its commercial importance was established it was decided to call it the Uncle Sam variety. This name was considered appropriate from the fact that it is probably a striking variation produced by the effect of the change of climatic conditions consequent on the introduction of Sumatra-grown seed into the United States, and while it was discovered in the Connecticut Valley it appears probable that it can be successfully produced under shade in Florida.

FIG. 10.—Typical leaf of Uncle Sam Sumatra tobacco, showing the ideal shape for cigar-wrapper manufacture. The veins are small and stand out almost at right angles to the midrib, which is very important for the economical cutting of wrappers.

The striking characteristics of this variety are extremely round leaves of fine texture, small fine veins growing at right angles from the midrib, the large number of leaves borne by the individual plants, and the wonderful uniformity of size and shape of leaves from the base to the top of the plants. In crops raised from the seed of this variety a large proportion of light-colored wrapper leaves are produced, which when wrapt on cigars have a smooth, glossy appearance. The leaves show uniformly a good burn in all practical and experimental tests, and there is no undesirable taste or flavor present or noticeable when the wrappers are smoked on cigars. The leaves have a peculiar and very characteristic habit of growth, standing out almost at right angles near the stem, and then drooping slightly near the tips. The quantity of seed produced by plants of this variety is very small, and very few and small suckers develop at any time during the growing season. In figure 9 is shown a typical plant of this variety, while figure 10 shows a typical leaf of this variety grown from self-fertilized seed.

The pedigree record of the original plants and their progeny shows an average production of 21 leaves to the plant, having an average length of 20½ inches and a width of 14½ inches. The average number of suckers is three and the size small. The average height of plants is 6 feet, and the average period from the date of setting out the plants in the field to the time of harvest is ninety days. The length of internode is 3½ inches and the circumference of stem 3½ inches. The plants have been particularly free from the attacks of fungous diseases, and the leaves have the necessary stretch, or elasticity, and strength to cover the cigar well without injury. The yield of wrappers in the manufacturing process has been exceedingly large and of the best quality.

FIG. 11.—Typical plant of the Cooley Hybrid tobacco. Connecticut Havana Seed, female parent; Sumatra, male parent. The hybrid retains the habit of growth and adaptability to Connecticut Valley conditions of the mother parent, combined with the improved shape, size, venation, and other characters of the male parent.

NEW VARIETIES PRODUCED BY HYBRIDIZATION AND SEED SELECTION.

THE COOLEY HYBRID.

The history of the origin of the Cooley Hybrid is as follows: Select plants of the Havana Seed variety grown by Mr. D. P. Cooley, Granby, Conn., were used as mother parents. Several flowers on these plants were emasculated at the proper time and pollinated with pollen produced by plants grown from Connecticut Sumatra seed in the season of 1903. From the plants grown from this seed, selections of the most desirable were made in 1904. From this crop typical seed plants were again selected, and the plants raised from this seed in 1905 showed as great uniformity as ordinary crops of the mother Havana Seed variety, so that the hybrid can be said to be fixt, and seed in small samples has been distributed to interested growers. An illustration of the Cooley Hybrid plant is shown in figure 11, while a leaf of this variety is shown in figure 12. Illustrations of the Cooley Hybrid tobacco grown under shade are shown in Plate X.

The Havana Seed variety has long, rather pointed leaves with large veins. Only the tips of these leaves are suited to cigar-wrapper manufacture, the middle and basal portions lacking the necessary quality for good wrappers. This portion of the leaves is used for binders and in some cases for blending with cigar-filler tobacco. Inasmuch as the value of the tobacco depends on its capacity for producing cigar wrappers, it is highly desirable and important that as much of the leaf be utilized for wrapper purposes as possible. By crossing this acclimated variety with the standard Sumatra variety a hybrid was secured which produces short, broad, well-rounded leaves with fine veins. In other words, the hybrid combines the hardy and acclimated characters of the Havana Seed with some of the important characters of the Sumatra variety. From the variations in the plants of this hybrid it has been found possible to produce about the type of plant that is best suited to cigar-wrapper manufacture which can be grown under the soil and climatic conditions of the Connecticut Valley.

FIG. 12.—Typical leaf of the Cooley Hybrid tobacco. Connecticut Havana Seed, female parent; Sumatra, male parent.

The general characters of the Cooley Hybrid distinguishing it from the mother Havana Seed variety are increased number of leaves; shorter, broader leaves with very small, fine veins; reduced seed production, and more even texture of leaf from tip to base. The average number of leaves is 16; length, 27 inches; breadth, 17½ inches; shape, very round; number of suckers, 2; size of suckers, small; height of plant, 29 inches; circumference of stem, 2¾ inches; length of internode, 2 inches; time of maturity, ninety-five days.

It is necessary that the seed of this hybrid be saved under bag to avoid the possibility of cross-pollination. If the seed is crost with other plants, particularly with plants belonging to other varieties grown in a region, it is probable that there will be considerable breaking up in type and consequent deterioration of the

value of the variety for cigar-wrapper production. It is likely that more or less variation will be developed in crops of this variety for several years, but that this variability will not be very marked. Small crops ought to be grown at first, even in the Connecticut Valley where the variety was produced. From these crops selections can be made in accordance with the directions given in this bulletin under the head of "The selection of seed plants," whereby acclimated strains of this variety adapted to local conditions, which will be an improvement over the present variety, can be secured.

THE BREWER HYBRID.

The history of the origin of the variety known as the Brewer Hybrid is as follows: Plants of the Connecticut Broadleaf variety raised from seed of the strain grown by Mr. N. S. Brewer, Hockanum, Conn., were crost in 1903 with pollen secured from plants grown in the Connecticut Valley from imported Cuban seed. Many crosses were also made in 1904. The plants raised from the hybrid seed in 1904 showed that a marked change had been effected by hybridization. The hybrid plants produced short, broad leaves of fine, even texture with small fine veins, an increased number of leaves with little increase in the height of the plants and, in some cases, a much improved type of plant for cigar-wrapper production.

FIG. 13.—Typical plant of the Brewer hybrid tobacco. Connecticut Broadleaf, female parent; Cuban, male parent.

Selections from the crop of 1904 were grown in 1905, and one strain in particular showed such fixity of type that it may be considered ready for distribution to growers.

In the Connecticut Broadleaf tobacco the large size of the leaves is correlated with large veins and rather coarse and inferior basal portions of the leaves. These basal parts of the leaves are only suitable in most cases for cigar binders and for blending with fillers. As

in the case of the Havana seed variety grown in this valley, the tips of the leaves produce the high-grade wrappers. It has long been recognized that a most important problem was the production of a smaller leaf with more uniform texture adapted for cigar-wrapper manufacture.

The Brewer Hybrid possesses many important characters that are distinct improvements over the Broadleaf variety. The average number of leaves is 21; length of leaves, 27½ inches; width, 19¾ inches; shape, very round; height of plants, 42 inches; circumference of stem, 2½ inches; length of internode, 2 inches; number of suckers, 2, of medium size. The time of maturity is eighty-five days. The suckering habit of the hybrid is rather unsatisfactory at the present time, for it seems to inherit the suckering tendency of the Cuban tobacco; but as some of the plants in this variety have been found to be comparatively free from suckers there is little doubt that nonsuckering strains can be developed by seed selection.

FIG. 14.—Typical leaf of the Brewer Hybrid tobacco. Connecticut Broadleaf, female parent; Cuban, male parent. The broad, very round leaf, fine venation, and other desirable characters of the Cuban tobacco are evident. These characters are combined in the hybrid with the burn, body, and taste of the Connecticut Broadleaf, the mother parent.

An illustration of the Brewer Hybrid is shown in figure 13. The typical shape and size of leaf of the hybrid are shown in figure 14.

In the case of both the Cooley Hybrid and the Brewer Hybrid the tobacco can be sold by the growers and utilized by the manufacturers as improved Havana seed and Connecticut Broadleaf tobacco, respectively. In this way their production will not disturb the established market standards, but simply meet the demands of the market for improved wrapper and binder tobaccos to the benefit of both the grower and the manufacturer.

PLATES.

DESCRIPTION OF PLATES.

PLATE I. FIG. 1.—A field of tobacco raised in Connecticut from imported Cuban seed. The result of using unselected Cuban-grown seed in the Connecticut Valley can be seen from a careful examination of this illustration, which shows a typical instance of the breaking up in the type of tobacco, due to the abrupt change of soil and climatic conditions. The branching type of plants bearing small leaves, constituting about one-third of the total number of plants in the field, was absolutely worthless for cigar-wrapper production, and many of the other variations from the normal Cuban type were of inferior quality, thus greatly reducing the yield and value of the crop. Fig. 2.—This uniform field of tobacco was produced by carefully selecting for seed production the best plants in the field shown in figure 1, and protecting the flowers from cross-pollination by the use of paper bags for two seasons. The undesirable types of plants were eliminated by this practise, and a uniform and desirable type secured, adapted to the soil and climatic conditions in Connecticut.

PLATE II. Fig. 1.—This type of plant found in Connecticut fields grown from freshly imported Cuban tobacco seed was selected for propagation. Fig. 2.—The progeny of a single Connecticut Cuban seed plant, similar to figure 1, showing the uniformity of type of plants grown from self-fertilized seed, and the marked similarity of every plant to the type of the parent seed plant.

PLATE III. The two uniform types of tobacco shown in this illustration were produced by sowing the seed of typical plants of these types growing in the same field and under similar conditions, free from cross-fertilization. These types of tobacco have been improved by careful selection of the best individual plants from year to year adapted to the purpose for which each type is produced. This experiment has demonstrated that the size, shape, venation of leaves, and other characters of tobacco plants can be propagated uniformly every year by judicious selection of seed plants of the type desired and the saving of the seed under bag.

PLATE IV. The introduction of Florida-grown Sumatra tobacco seed in the Connecticut Valley was followed by a breaking up of the type of this tobacco. Among these types, few of which were desirable, and many undesirable, the two types shown in this illustration were found. The seeds of typical plants of these types were saved under bags, from which uniform strains were produced the following season. Both of these types of tobacco are valuable for growing under shade, and the two rows, one of each type, growing side by side, offer incontrovertible proof of the value of the methods of seed selection described in this bulletin in the production of uniform types of tobacco.

PLATE V. The two plants shown in this illustration, one bearing few small suckers, and the other many large suckers, represent the average variability of tobacco plants as regards the sucking habit. The plants are of the same variety, grow side by side in the row, are of the same age, and were grown under similar conditions in every respect. The leaves of the plant bearing few suckers are uniformly wide and round, while the leaves of the plant bearing large suckers are long and pointed, and have a tendency to vary markedly in size from the top to the base of the plant. This character is hereditary and consequently the suckering tendency may be controlled by tobacco growers by seed selection.

PLATE VI. Fig. 1.—The characteristic variability of tobacco plants as regards time of maturity, as shown in this illustration, is a matter of common observation in tobacco fields. The difference in the time of ripening of the leaves in the individual plants is of special importance in the tobacco crop, from the fact that in most cases all of the plants in the field are harvested at one time, and overripe or underripe leaves are inferior in quality. For this reason it is desirable that the plants mature uniformly thruout the field. Fig. 2.—The two rows of tobacco plants shown in this illustration demonstrate the possibility of securing uniform early or late strains of tobacco by seed selection. The two rows were grown under the same conditions.

PLATE VII. The character of the burn of leaves of individual tobacco plants varies in a marked degree, even among plants of the same variety grown under the same conditions and treated alike in the curing and fermenting processes. The two rows of plants in this illustration were grown from the bagged seed of two plants of the same field, growing side by side, one a plant producing good and the other poor burning leaves. These two progeny rows inherited uniformly the character of burn of the parent plants, demonstrating that it is possible to improve the quality of burn in a variety of tobacco by seed selection.

PLATE VIII.—The Connecticut-grown Sumatra tobacco produced a number of types of tobacco very different in all characters. The two rows of plants shown in this illustration are the progeny of two representative plants of these types, grown under the same conditions and showing the striking uniform inheritance of the characters of the parent plants.

PLATE IX. Fig. 1.—The row of tobacco plants in the left in this illustration, raised from heavy seed, shows the more vigorous growth, earlier maturity, and greater uniformity of plants raised from heavy seed, compared with the less vigorous plants raised from light seed shown in the row on the right. Fig. 2.—The row of small plants shows the dwarfing effect of the root-rot in Connecticut Sumatra tobacco, while the row of vigorous plants shows a resistant strain secured by seed selection.

PLATE X.—The two rows of the Cooley Hybrid tobacco shown in this illustration were grown under shade in the Connecticut Valley. The uniformity of plants and the shape, size, and character o fleaves shown in these rows are characteristic of this variety of tobacco. There is no decided breaking up in type following hybridization, as is the case in other plants.

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FIG. 1.—CONNECTICUT CUBAN TOBACCO PLANTS RAISED IN 1903 FROM UNSELECTED FRESHLY IMPORTED SEED, SHOWING GENERALLY UNDESIRABLE TYPES.

FIG. 2.—CROP OF CONNECTICUT CUBAN TOBACCO PLANTS RAISED IN 1905 FROM SEED SAVED FROM BEST PLANTS SELECTED FROM THE FIELD SHOWN IN FIGURE 1, SHOWING UNIFORMLY A DESIRABLE TYPE.

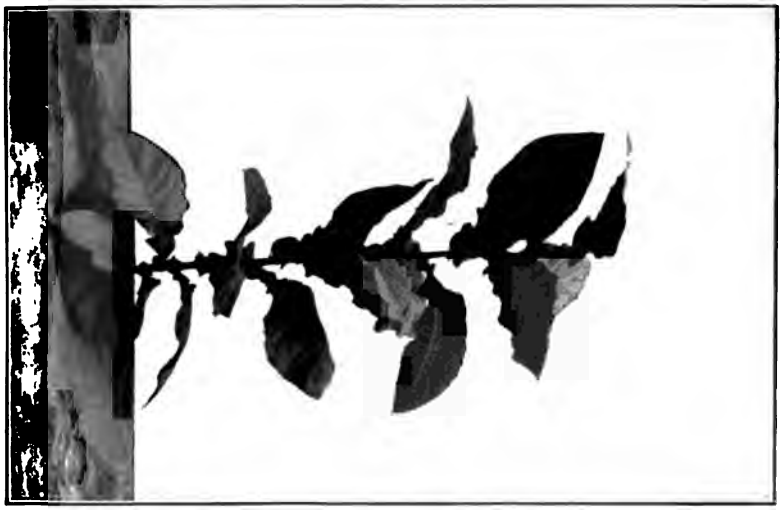

FIG. 1.—TYPE OF CONNECTICUT CUBAN TOBACCO PLANTS SAVED FOR SEED PRODUCTION.

FIG. 2.—THE PROGENY OF A SINGLE PARENT PLANT OF CONNECTICUT CUBAN TOBACCO RAISED FROM SEED SAVED UNDER BAG.

TWO TYPES OF CONNECTICUT CUBAN TOBACCO WHICH HAVE BEEN INBRED FOR THREE YEARS, SHOWING THE VALUE OF THE PRACTICE OF INBREEDING IN TOBACCO.

TWO ROWS OF CONNECTICUT SUMATRA TOBACCO SHOWING VARIATION IN TYPE. ROW ON RIGHT, GREENLEAF TYPE; ROW ON LEFT, SUMATRA TYPE.

TWO TOBACCO PLANTS OF SAME AGE SHOWING VARIABILITY IN THE PRODUCTION OF SUCKERS.

FIG. 1.—FOUR TOBACCO PLANTS OF THE SAME AGE, SHOWING VARIATION IN TIME OF MATURITY.

FIG. 2.—TWO ROWS OF CONNECTICUT BROADLEAF TOBACCO, SHOWING THE POSSIBILITY OF THE PRODUCTION OF EARLY STRAINS. ROW ON RIGHT RAISED FROM THE SEED OF AN EARLY PLANT, AND ROW ON LEFT FROM SEED OF A PLANT MATURING AT THE USUAL TIME.

TWO ROWS OF CONNECTICUT SUMATRA TOBACCO GROWN UNDER UNIFORM CONDITIONS. ROW ON RIGHT, POOR BURNING TYPE; ROW ON LEFT, PERFECT BURNING TYPE.

TWO ROWS OF CONNECTICUT SUMATRA TOBACCO SHOWING VARIABILITY IN TYPE. ROW ON RIGHT, BELGIAN TYPE; ROW ON LEFT, CRUMPLE TYPE.

... PLANTS SHOWING THE RESULTS OF THE

FIG. 2.—A ROW OF CONNECTICUT SUMATRA PLANTS AFFECTED WITH WILT IN COMPARISON WITH A ROW OF PLANTS OF THE SAME VARIETY GROWN

TWO ROWS OF COOLEY HYBRID TOBACCO GROWN UNDER SHADE.

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